The Mississippian Lime is a significant tight oil play that lies beneath America’s heartland, where Oklahoma meets Kansas. Over the past five decades, the play has produced a fair share of crude oil and natural gas from some 14,000 vertical wells completed using conventional completions methods.

In recent years, thanks to the advent of horizontal drilling and hydraulic fracturing, the Mississippian Lime has piqued the interest of operators venturing into unconventional plays across the U.S. But unlike the Bakken, the Eagle Ford, and the Barnett formations, this play is not a shale.

The Mississippian Lime is a vast, relatively shallow limestone formation topped by a low-permeability, high-porosity formation called the Mississippi “chat”—a combination of chert, limestone, and dolomite. The play tends to be “oily” to the east (toward Tulsa, Oklahoma) and “gassy” to the west (toward the Oklahoma Panhandle). It can range in depth from 2,000 ft to 7,000 ft (610 m to 2134 m). Bottomhole pressures can drop from 2,500 psi to 500 psi in a matter of months. It’s a very dynamic formation, producing a combination of oil, gas, and water—lots and lots of water.

However, with Baker Hughes ProductionWave™ solutions that feature innovative artificial lift technologies that target these very conditions, Oklahoma City, Oklahoma-based SandRidge Energy is extending the life of its wells and seeing post-fracture production rates increase in a play that many operators found to be more trouble, and expense, than it was worth.

A plan to maximize value
Since acquiring its leases in 2010/2011, SandRidge Energy has drilled more than 1,200 horizontal wells in the Mississippian Lime play—all of which have required some form of artificial lift because of normal production declines, sand, and the presence of gas and liquids.

Initially, SandRidge chose gas lift systems for the majority of its wells. However, gas lift tends to maintain a higher reservoir pressure early in the life of the well and can limit recovery.
“The challenge with gas lift is that you have to inject natural gas into the well to mix with the fluid stream in order to lighten the load and to lift those fluids to surface,” explains Brian Pugh, director of operations for SandRidge’s Mid-Continent area. “Inherently, you get backpressure on the well, which pushes on the formation and impedes the well from producing fluids as efficiently as it could if there were no backpressure.

“Over the past few years, SandRidge has looked for ways to improve upon its production curve and to maximize value. Our challenges were many: a wide range of bottomhole pressures, tremendous volumes of water and oil, and significant gas production.”

Some older wells in the play make 1,000 BFPD plus another million or 2 million ft³/D of gas. “With typical oil cuts around 4%, we can move approximately 1 million gross BWPD in the play,” Pugh says. “Rod pumps have certainly been effective in some applications but not where we have fluid rates this high.”

Pugh says that SandRidge had considered ESP systems as a lift alternative because of their ability to get significantly lower bottomhole pressures, which takes the backpressure off of the formation and allows the formation to flow more freely and to increase production. “However,” he says, “the pumps operate more efficiently in a fluid-rich environment and we’ve had instances where we might be running for a half hour or more with almost zero fluid going by the pump due to gas slugs. Additionally, high levels of gas accumulation in the centrifugal pump prevent fluid progression, which can create gas locking and cause the ESP system to shut down.”

Looking for an artificial lift method that could withstand the myriad of challenges in the play and that would enable the company to most profitably produce its wells longer and at higher volumes, SandRidge turned to Baker Hughes.

“What we came up with is a premium three-step well management process that incorporates the Baker Hughes ProductionWave™ solution,” Pugh says.

**Deploying a flexible, step-down process**

The ProductionWave solution is a customized resolution for individual operator needs. “It can be any combination of reservoir modeling, technology delivery, services, or commercial models that expand the viability—and return on investment—of ESP system deployments in low-flow-rate environments,” explains Nathan Holland, Baker Hughes Artificial Lift director for the Central U.S.

“For SandRidge, we’re applying a solution in line with its economic drivers—mainly delivering greater production and value over the life of its wells,” Holland says. “By working together, engineers from both companies are choosing equipment and planning for the most uptime potential of those wells throughout their life cycle, which ultimately leads to more predictive and proactive operations.”

The ProductionWave solution includes FLEXPump™ series pumps—technology that can produce at flow rates from 10,500 B/D to as low as 50 B/D—that can be changed out as production rates decline. The pumps’ effectiveness is enhanced through advanced capabilities for gas handling and sand control, which is also a concern for operators fracturing wells in the Mississippian Lime play.

“Moving the volumes of fluid that are seen in this play is in the core sweet spot of the FLEXPump series pumps,” Holland says. “These pumps are designed to deliver upwards of 75% efficiency. Recent technology developments, coupled with a better understanding of the play, have enabled us to see high operating efficiency even when we are moving fluid volumes well below 500 B/D.”

SandRidge is installing ESP systems in all of its new wells and it began a conversion program in 2013 to switch its gas lift systems to ESP systems (and to a limited number of rod lift systems). To date, SandRidge has converted from gas lift on more than 100 wells. In addition, it has approximately 300 potential candidates to convert from gas lift to low-volume ESP systems or rod lift.

“SandRidge was an early adopter of this new breakthrough low-volume, low-pressure ESP technology from Baker Hughes that uses a premium, step-down process to get the optimum production out of our wells as they level off,” Pugh says.

The process begins with the installation of a large-volume pump with an operating range from 10,500 BFPD to 2,500 BFPD. It’s installed deep into the well, and as the well produces down to below the operating limit of that pump, it’s pulled and replaced with an appropriately rated pump.

“Essentially, we walk down the decline curve with a different-sized ESP system, which ultimately allows us to put the well on a beam pump once it starts producing below 50 B/D—the current limit for an ESP,” Pugh says. “Another great thing about this program is that the pumps are transferrable. Once they reach the end of their operating range, they can be pulled and used over and over again in other wells. That not only maximizes the value of the well, but it also limits the cost of the ESPs.”

**Stepping up production**

SandRidge has seen considerable improvements in production by lowering the backpressure against the reservoir rock using ESP technology instead of gas lift.
In one study, SandRidge compared production in an ESP-fitted well to that of a competitor’s gas lift well drawing from the same reservoir. A Baker Hughes P35 pump, which has an operating range from 4,500 B/D to 1,100 B/D, was installed. After 70 days on line, the SandRidge ESP well yielded 185% greater production than the competitor’s gas lift well.

“It cost USD 2.6 million to drill and complete that particular well,” Pugh says. “With gross cumulative revenue of USD 3.8 million through the first 70 days of production, the well more than paid for itself.”

Under its gas lift conversion program, SandRidge has seen equally impressive numbers. In one well, a gas lift system was replaced with a FLEXPump 10, which has an operating range from 1,650 B/D to 250 B/D. “In a four-month span, we were able to improve BOE by 80% and oil uplift by 60%,” Pugh says.

And in another conversion, SandRidge replaced a gas lift system with a FLEXPump 3.2 after production had declined to below 500 B/D. “With the FLEXPump 3.2, which has an operating range down to 50 B/D, we reduced backpressure by 475 psi and increased BOE 98% and oil uplift 56% compared to the gas lift well,” Pugh says. “It actually added USD 1.2 million in value and an additional 53,000 barrels of reserves, and it proves that backpressure really does matter.”

**Making continuous improvements**

Counting new wells drilled and converted wells, Baker Hughes has installed nearly 600 ESP systems for SandRidge Energy in the Mississippian Lime play. Holland says he expects the number of ESP installations to remain steady through 2015.

“We are continuously looking at new technologies that will continue to meet SandRidge’s needs and make them successful,” Holland says. “We are working to decrease the number of ESP strings from three to two to potentially one. And we understand their need for equipment to fit into 4½-in. casing and also for technology that helps prevent sand from coming into the ESP system.

“In addition, we’re early in the life of a proprietary shroud gas mitigation technology—another key element in the ProductionWave solution designed for SandRidge—that is proving to be successful. The shroud technology basically keeps the well in operation through any gas event and it allows the operator to easily restart the well in the event of a shutdown caused by a power event.”

In Q3 2014, Baker Hughes installed approximately 150 ProductionWave systems with proprietary shroud technology and was projecting roughly that same number for Q4.

“By partnering with Baker Hughes—arguably the best provider of ESP technology in the industry—we have been able to optimize the productive life of these wells, and even bring some back on line altogether, through the use of the shroud technology,” Pugh says. “And, we’ve been able to bridge our production rate gap through the use of ESP systems with the FLEXPump series pumps that can get us all the way to the late life of the wells when there are lower volumes and lower pressures. We’ve seen some tremendous results and are truly maximizing value in these gas lift wells by converting them to ESP wells.”

Brian Pugh, director of operations for SandRidge’s U.S. Mid-Continent area