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Oil and Gas  
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# COALBED METHANE

DECEMBER 2005



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Houston, Texas 77027  
Tel: (713) 993-9320  
Fax: (713) 840-0923  
www.eandpnet.com  
www.oilandgasinvestor.com

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# COALBED METHANE

**T**he popularity of coalbed methane (CBM) continues to grow in North America, and the fundamental reasons for this suggest that natural gas producers will be targeting coal seams for quite some time.

Conventional natural gas reservoirs are largely tapped out, forcing producers to pursue gas that is more difficult to extract. However, in a market in which gas sells for \$7 and more, this is far from an unattractive proposition. Technological advances have substantially mitigated the physical and economic challenges posed by coal seam gas. While gas production from coal seams is relatively modest, CBM reservoirs are exceptionally long-lived, which makes them an attractive complement to quick-producing and fast-declining conventional reserves.

This edition of *Oil and Gas Investor's* Coalbed Methane special report—the fourth annual—looks at how CBM's technological challenges are being met and examines some of the hottest plays, where producers are investing in the next frontier of America's domestic natural gas future.

The Big George coals in Wyoming's Powder River Basin caught the attention of Anadarko Petroleum back in 1995, and the company's early enthusiasm is expected to pay off handsomely. Two significant acquisitions in 1995 substantially increased Anadarko's acreage position in the Powder River Basin, and the company expects to drill 200 Big George wells next year.

"We're in the early stages, so we do have a good growth profile out there for quite a while," says Brad Miller, Anadarko area manager for CBM development.

Eastern Oklahoma's Middle Pennsylvanian Hartshorne coals in the Arkoma Basin drew El Paso Production Co. to the area in late 1999. Initially, vertical wells were a disappointment. But in 2002 El Paso began drilling horizontal wells. The horizontal program grew to 100% of the company's Hartshorne drilling last year. More recently, the focus has been on growing production through lateral extensions.

In the Atlantic Rim play—on the eastern edge of the Washakie Basin in the southeastern third of the Greater Green River—Anadarko, Warren Resources and Double Eagle Petroleum are awaiting Bureau of Land Management approval of an environmental impact statement. Once that comes through, partners Warren and Anadarko will begin in earnest their drilling program, currently expected to culminate in 1,800 wells and ultimate production of 1.8- to 2 trillion cubic feet.

Operators continue to learn how best to produce gas from coal seams. Horizontal drilling and completion technologies continue to evolve. Produced water remains a significant obstacle to CBM production. However, operators are showing foresight in their early drilling of water injection wells, examination of water treatment technologies and, in Anadarko's case, construction of a water pipeline. Such efforts make clear CBM's attractiveness.

Leslie Haines  
Editor-in-chief  
*Oil and Gas Investor*

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About the Cover: The Wyoming prairie is punctuated by the mast of a rig drilling coalbed-methane in Sheridan County. (Photo by Lowell Georgia).

# CBM is the Place to Be

*When it comes to natural gas in North America, the low-hanging fruit has been picked. That's why operators have turned their attention to unconventional resources, in particular coalbed methane.*

**Article by Joe Fisher, Editor, *Energy Markets***

**G**as-bearing coalbeds are easy to find; the challenge is getting the gas out. Here are three reasons operators think it's worth the effort.

## Big George

In the Powder River Basin, the Big George coals are shaping up to be the porterhouse of coalbed-methane (CBM) plays. They are thick, marbled with gas and have operators salivating for a piece of the action.

Wyoming's Big George coals are about 60 miles long north-to-south and about 30 miles wide. They rest in the central part of the Powder River Basin. The play's existence has been known for about 50 years; the coal—too deep for surface mining and too thick for underground mining—was discovered during uranium exploration. Big George was ignored for a long time until rising natural gas prices turned the industry's attention to CBM, and Big George was remembered for the natural gas it might hold.

Permitting took off in "leaps and bounds" during spring 2005. Johnson County, Wyoming—where Big George resides—had more permits filed this year than any other county of the state, says Bj Kristiansen, who heads up Wyoming's CBM Coordination Coalition.

"I think the Big George play could be the most significant coalbed-methane play in the country for that type of sub-bituminous coal. Its sheer volume, tonnage, really makes it a target that's fairly unique in probably even the world," Kristiansen says.

Anadarko Petroleum has made the Big George the focus of its Powder River operations since 1995. The company was the first to drill pilots in the area and last month had drilled 200 wells, with 120 on production making

about 50 million cubic feet per day (MMcf/d) in its County Line project.

Concentrating its acreage position, Anadarko in the first quarter acquired ConocoPhillips' Powder River interest, increasing its position to 132,000 gross acres from 30,000. Since then, Anadarko closed a deal with Kerr-McGee to pick up another 40,000 gross acres in the Big George coal, most of which was incorporated with increased working interest in the ConocoPhillips piece, says Brad Miller, area manager of Anadarko's CBM development.

"We think we have the opportunity and the potential to drill in excess of 1,500 wells in the area through this development. We've grown this asset dramatically in the past year," he says.

Next year is expected to bring another 200 Big George wells for Anadarko "as fast as we can get permits from the feds," Miller says, with the focus on the County Line project. Additionally, plans include pilots on the company's significant acreage in the Dry Willow and Table Mountain plays.

In focusing on the Big George, Anadarko has "kind of avoided" the Wyodak play, Miller says. "The main reason is thickness and gas content."

Gas content in the Wyodak coals ranges between 20 and 60 standard cubic feet (Scf) per ton. In the Big George, gas content can range between 20 and 100 Scf per ton, with most of Anadarko's holdings containing in excess of 50 Scf per ton, says Miller.

"Though it has almost doubled the average gas content of the Wyodak, the production curve fits that same profile," he adds.

Peak rates for Wyodak wells are about 150,000 cubic feet per day on average, and the peak rate for the typical Big George well is about 350,000

cubic feet per day. Finding costs compare favorably to Big George as well. Miller estimates Big George at about 60 cents per thousand cubic feet a day versus 85 cents in the Wyodak.

The economics of Big George make for finding costs of about half of those for conventional plays, Miller says, making the play a worthy, long-lived complement to Anadarko's conventional gas portfolio.

"That's what CBM in Anadarko's portfolio does. It brings in low-cost reserve additions, and we can do it with significant size, and we have an excellent growth profile. CBM is in its early stages of development as compared to most other gas opportunities in the Lower 48, which are in the mature stages. We're in the early stages, so we do have a good growth profile out there for quite a while," he says.

Anadarko isn't the only one. This year, Devon Energy was expecting to drill about 175 Big George wells out of about 200 wells overall in the Powder River Basin with about a 50% working interest. Plans for next year call for another 175 Big George wells out of about 250 in the Powder with between 60% and 70% working interest.

The Bureau of Land Management permitting process has slowed development, says Devon's Steve Krueger, CBM reservoir supervisor. Unlike the Wyodak play, Big George areas are dominated by federal acreage, and companies have been able to drill only in patches across the extent of the play.

Devon produces about 27 MMcf/d from three Big George projects. There are two others, one undeveloped and one where dewatering was about to begin this fall. Gregg Jacob, Devon western division reservoir manager, says he is expecting ultimate recoveries

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from Big George to be anywhere from two to four times those of a typical Wyodak well. However, the Big George still has its mysteries.

“Some of the development has been spotty and seems to be controlled by geological features that separate good areas from bad,” says Krueger. “The Wyodak appeared to be a little bit more of a blanket type of development without those kinds of separating geological features.”

In the Powder River Basin, Devon is spending about \$30 million this year and expects to spend about \$40 million next year, about 75% in Big George. Having been in the Wyodak play for seven or eight years, the next seven or eight are going to be focused on the Big George, where CBM’s long-lived reserves story is just beginning.

“I don’t foresee a bust in this particular play for 20 to 30 years, primarily because of the sheer volume of coal down there that’s available,” says Kristiansen. “The resource is so vast, because the reservoir itself is so big, that I very much doubt that the boom and bust cycle will ever take place again.”

**Hartshorne**

Oklahoma CBM production dates back to the 1930s; however, the current generation of CBM activity began in the late 1980s when Bear Production



Coal is mined throughout the Powder River Basin, including this site at Spring Creek Mine, near Deckers, Mont. (Photo by Lowell Georgia)

Co. drilled a couple dozen vertical wells in Kinta Field in Haskell County. Other firms entered the play in the early 1990s.

Today, Haskell, Pittsburg, Latimer and LeFlore counties in eastern Oklahoma are seeing increased activity as operators target the Middle Pennsylvanian Hartshorne, a bituminous coal occurring in seams between 3 and 8 feet thick throughout much of the Arkoma Basin. Oklahoma’s coalfield is divided into the Northeast Oklahoma Shelf and the Arkoma. The Hartshorne splits into what are known as the upper and lower Hartshorne coals; however,

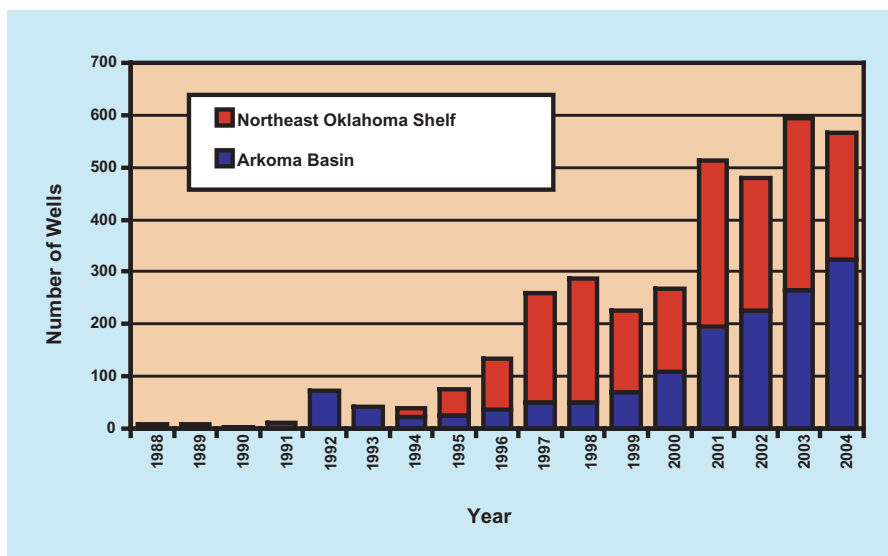
most operators just call it the Hartshorne. The lower Hartshorne coal is thicker and is the target of more drillbits, says Brian Cardott, a geologist with the Oklahoma Geological Survey.

Cardott tracks CBM activity and maintains a database of completions. There have been up to 600 completions a year in the Northeast Oklahoma Shelf and the Arkoma combined. There were 328 completions in the Arkoma Basin alone last year. So far, that’s the maximum, but it represents one more step in what has been a steady rise in Arkoma completions during recent years: 118 in 2000; 194 in 2001; 228 in 2002; and 269 in 2003. As for the longevity of the Hartshorne play?

“The easy answer would be there’s no end in site,” says Cardott.

The vast majority of the Arkoma’s wells are horizontal. Vertical wells had been a disappointment until the late 1990s Mannix Oil Co. Inc. of Tulsa pioneered horizontal drilling in the Arkoma. Williams Production Co. acquired the operator in 2001.

El Paso Production Co. entered the Hartshorne play in late 1999 with vertical wells and conventional fracturing and had marginal success. In 2002, the company began its first attempts at horizontal drilling in the Hartshorne. The horizontal program was expanded in 2003, and 100% of El Paso’s Hartshorne wells were horizontal last year. During the past year or two, the



Coalbed-methane well completions in Oklahoma have steadily increased since 1991. (Chart courtesy of Oklahoma Geological Survey)

company has focused on cost-efficient lateral extensions and is able to drill laterals in excess of 4,000 feet in the Hartshorne. El Paso is in the beginning stages of exploring new fracturing techniques in the Hartshorne. While expansion of fracturing efforts is planned, availability of frac crews is expected to be an issue.

El Paso's production from the Hartshorne was 21 MMcf/d net in November, up from 14 MMcf/d in January.

"The success on extending these laterals has translated into much better productivity per well," says Bill Griffin, senior vice president of El Paso Production's onshore division. Average production per horizontal well in the Hartshorne is 185,000 cubic feet per day, gross. The average rate on wells drilled in 2005 is 282,000 cubic feet per day.

To stay efficient and keep costs down, El Paso is pursuing an "assembly line" drilling strategy with two rigs and

sometimes a third, drilling about 70 wells a year in the Hartshorne. Sometimes, however, there is trouble getting rigs.

"The acceleration of the Fayetteville Shale play in that same basin has started to strain some resources a bit," explains Griffin.

**"It's one of the  
highest gas content  
coals in the country..."**

—Kevin Heringer, Vectra

Rig procurement might be a problem, but once gas is produced, there is plenty of infrastructure to get it to market.

"One of the nice things about the Hartshorne play, unlike a lot of other CBM areas, is that you're sitting right in

the middle of a producing conventional shallow gas basin," says Griffin.

Privately owned Vectra CBM LLC has made horizontal drilling for CBM its specialty and the Hartshorne its playground, where it currently finds no need for well stimulation. "It's one of the highest gas content coals in the country that everyone has always known about that technology has finally caught up with," says Vectra partner Kevin Heringer.

The Littleton, Colo.-based company operates 89 wells, including 66 horizontal CBM wells within the Arkoma Basin. In the 12 months preceding November, Vectra completed more than 40 horizontal CBM wells and plans to drill a minimum of 50 in the Arkoma next year.

The high gas content, low permeability coals are particularly attractive to Vectra given its horizontal technology. Vectra has been drilling to vertical depths between 1,500 and 3,100 feet. Its typical horizontal lateral is 2,700 feet



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with the longest being about 4,100 feet. However, beyond about 3,000 feet of lateral, the economics make longer laterals not worth the effort, says Vectra partner Cal Cahill, a former service company employee who is less of a well stimulation proponent than he used to be, at least where CBM is concerned.

“We create enough permeability through the drillbit versus trying to go in and do a fracture. With most coals, because of your cleat pattern, I think horizontal is going to work better than stimulation,” Cahill says.

The focus on horizontal drilling began three years ago after Vectra drilled a number of vertical wells and completed them with large frac jobs, with “dismal” results. Recently, Vectra drilled horizontal wells to offset previously drilled and fractured verticals that were producing less than 30,000

cubic feet per day. The horizontal wells had initial rates exceeding 500,000 cubic feet per day and are expected to produce more than 800 MMcf during their lives.

“We think we’re in a really good play,” says Heringer. “There are years of development left here. We believe the coal has a wonderful future, and the drilling technology and production practices that we’re using will continue to improve.”

### Atlantic Rim

It’s currently up to the BLM to release what could be next year’s blockbuster in CBM: the Atlantic Rim project on the eastern edge of the Washakie Basin in the southeastern third of the Greater Green River. That’s when a decision on an environmental impact statement (EIS), begun in July 2001, is finally

expected. But don’t bother lining up for tickets; acreage on the 60- by 8-mile play is locked up by Anadarko, Warren Resources and Double Eagle Petroleum, and they’re anxious for the show to start.

The play is laden with thinner, harder coals, akin to the Black Warrior and San Juan basins, with gas contents higher than those found in the Big George and Wyodak plays.

“We believe that we probably have 1,800 well locations on a combination of 80- and 160-acre spacing, and we anticipate producing an average of 1- to 1.5 billion cubic feet per well,” says Warren CEO Norman F. Swanton. “If we take the lower number, we’re looking for 1.8- to 2 trillion cubic feet of potentially recoverable reserves, which we share with Anadarko.”

Warren and Anadarko are 50-50



Ed Griebel, field foreman for Anadarko’s Atlantic Rim operations, stands on an outcrop in Utah, where at least six dark seams of coal are clearly visible in the rock layers. The layering is similar to that found in the Atlantic Rim area where Anadarko is developing one of its coalbed-methane projects. (Photo courtesy of Anadarko Petroleum)



partners in the play and jointly own a backbone pipeline through the center of the project where their Sun Dog pilot is located. Double Eagle's Atlantic Rim pilot is called Cow Creek.

Warren came to the Atlantic Rim after being shut out of further participation in the Powder River by that basin's costly acreage. Its Denver investment partners assembled a substantial portion of the Atlantic Rim play and test wells were drilled.

"We liked what we saw; we bought everyone out of the play," he says.

That was about 200,000 gross acres. Across the north end of the Atlantic Rim lies Anadarko's land grant acreage, obtained through its acquisition of Union Pacific Resources, a former subsidiary of the Union Pacific Railroad.

"Anadarko contributed its acreage from the land grant strip, which cross-hatched with us perfectly in the north end, and we already had the southern block, so we pretty much blocked out

what we considered to be the preferential drilling fairway," recalls Swanton.

**"We think it's one of the higher-quality CBM plays out there."**

—Brad Miller, Anadarko

Atlantic Rim reminds Swanton of the highly successful Drunkard's Wash CBM field in Utah's Uinta Basin. It has high gas content (250 to 500 Scf per ton), high permeability, shallow drilling depths and pipeline-quality gas. Additionally, Warren is able to re-inject 100% of produced water since project economics sup-

ported the company's previous decision to drill water injection wells.

"The coals lie fairly flat. They outcrop to the east and then they dip at about three degrees," Swanton says. "And when we get to the western part of the property, the coals in the Mesaverde plunge off a hinge line that runs in kind of a boomerang fashion down the play and creates natural fracturing and permeability."

While Warren and Anadarko wait for EIS approval, they are allowed to drill up to 200 wells. Double Eagle has used the waiting period to prepare water handling facilities, perforate additional coals in existing wells and test some deeper objectives at the Cow Creek Field. Anadarko's Miller says that five pilot programs are showing good results, and in November the partners were producing 7 MMcf/d from 70 wells.

"We think it's one of the higher-quality CBM plays out there," says Miller. □

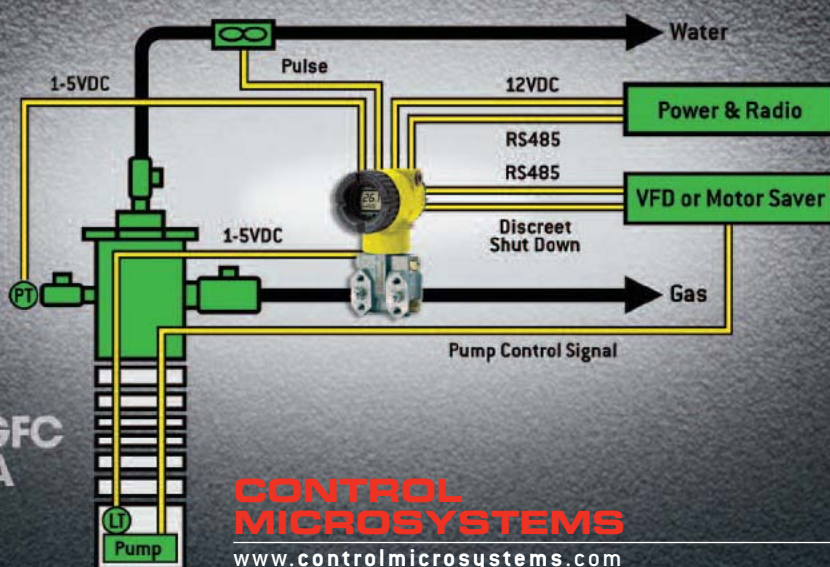
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# CBM Technology on the Rise

*Along with gas from shales and tight sands, coalbed methane is categorized as an unconventional resource or “previously unattractive.” Higher gas prices and advances in technology, however, have made these resources not just economic but desirable.*

**Article by Joe Fisher, Editor, *Energy Markets***

**W**hile not particularly hard to find, at least not any more, coalbed methane (CBM) is hard to get out of the ground and presents environmental obstacles, particularly regarding produced water disposal. However, these and other challenges are being addressed by significant technological advances and business innovation. Coalbed-methane operators now benefit from expanding industry capabilities in dewatering practices, reservoir characterization, horizontal drilling, multi-seam completions, coal fines management, information technology and others. More knowledge to produce more unconventional gas is in the offing as research and development efforts are in line for increased funding from the recently passed Energy Policy Act.

“What we’re faced with now in coalbed methane is very typical of many gas resources, certainly with the overall resource in the United States,” says Kent Perry, director of exploration and production research at the Gas Technology Institute.

The easiest resources and the easiest production have been tapped out. Coalbed methane is now starting to realize the challenge of thinner coal seams. In the past, seams might have been tens of feet thick. Now there are multiple coal seams that might be 1 or 2 feet thick. There are issues then of how to drill and best complete wells in that kind of environment.

## **Sideways can be better**

The past five years have seen significant advances in the application of horizontal drilling in CBM plays, says Scott Reeves, executive vice president of

consulting firm Advanced Resources International.

“Prior to that, people had tried horizontal wells in coals really without a tremendous amount of success. But now you’re seeing in the Arkoma Basin some success being achieved with conventional horizontal wells,” he says.

For instance, last year El Paso Production Co. drilled an immediate horizontal offset to a vertical well in Le Flore County, Oklahoma, which had been producing 34,000 cubic feet per day after peak production of 90,000 cubic feet per day. The horizontal well currently produces with sustained rates of 650,000 cubic feet per day, says Bill Griffin, El Paso senior vice president, onshore division.

CDX Gas has enjoyed success with its pinnate drilling technology, notes Reeves. The technology utilizes multiple laterals that form something of a fishbone pattern.

“That’s been able to really make some plays successful that weren’t before, particularly in the Appalachia where I think it’s probably had the most success. There are usually a number of tight coals out there, and this technology is able to have a fairly small footprint yet be able to drain a very large area,” he says.

However, pinnate drilling is not universally applicable, notes Matthew Blauch, Halliburton principal technology professional. Different reservoirs present different challenges requiring different solutions. Halliburton has been working on remedial treatment technologies, particularly important in CBM where wells have long production lives with comparatively low daily production.

“For a long time everyone pretty much lived with the assumption that there wasn’t much you could do to change the baseline production. You went out and you fraced a well and you got what you got and that was it,” Blauch says.

Wells often were and still are re-fraced to improve their performance. However, other remedial treatments can be more cost effective.

Halliburton recently developed technology to deal with coal fines, particulate coal that can clog CBM wells and gum up equipment.

“Basically, it locks the fines in place. If the well has already been plugged or clogged with fines, we’ll basically back flush those fines and lock them down, take them out of the equation,” says Blauch.

## **Do-it-yourself innovation**

In at least one instance, the challenge of multi-seam completion has inspired an operator to develop its own technology. St. Mary Land & Exploration is active in the Hanging Woman Basin, a sub-basin in the northern Powder River on the border of Wyoming and Montana. The Denver company’s project targets thinner coals in multiple seams.

“We did run our economics assuming that we couldn’t do multi-seam completion, which would have meant that in each of the shallow, intermediate and deeper coals, each of our packages has three different coal seams, which would mean you’d have to drill a separate well for each of those coal seams,” says Mark Hellerstein, St. Mary president and CEO.

Fortunately for St. Mary, an



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*Genesis Gas & Oil LLC*

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*Email: [jmohajir@genesisgo.com](mailto:jmohajir@genesisgo.com)*

engineer working on the project is the son of a former Baker Tools employee. Duane Zimmerman, CBM operations manager for St. Mary subsidiary Nance Petroleum, came up with an innovative packer tool for which the company has applied a patent. Hellerstein says the packer tool works better than what is available elsewhere in the industry for multi-seam completions.

### Canadian coal

The United States has seen far more CBM development than western Canada. However, that is beginning to change.

“Western Canada has a tremendous, tremendous volume of coal. And yet the coalbed-methane production there is practically zero compared to all of the production in the United States,” says

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**“The paradigm shift has occurred to where operators are looking at each basin as its own entity.”**

—Mathew Blauch,  
Halliburton

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Perry. “But recently there’s been a lot of work done looking at the coal seams there and quite a bit of drilling. One of the overriding issues on that overall coals system in Canada was just a lack of permeability.”

Reeves marks Canada’s Horseshoe Canyon, where the coal is very dry, as a hot new play.

“What they’re doing up there is straight dry nitrogen fracturing and a system of coiled-tubing-conveyed fracturing systems that have allowed the operators to frac multiple zones very quickly in a single day, even without using aqueous fluids, which can damage the reservoirs pretty badly up there. That’s a place-specific technology, I think,” he says.

Indeed, much of the work being done in CBM has become more place-specific.



One of Devon Energy’s CBM drilling sites targeting the Big George formation in the Powder River Basin near Gillette, Wyo. (Photo courtesy of Devon Energy)

"I think what has happened over the last 10 years is the understanding that not all CBM basins are alike; they're all very different," says Blauch. "So the paradigm shift has occurred to where operators are now looking at each basin as its own entity and taking the knowledge and innovations collectively and applying the right technology to the right problem. I think a lot of it has to do with application of the right technologies."

### A better look below

Getting a better look at—and understanding of—reservoirs is key to knowing how to drill wells and complete them as well as how much gas production can be expected. Advanced Resources International is linking Monte Carlo simulation with reservoir simulation.

"It enables us to probabilistically forecast production in areas where there's a tremendous amount of uncertainty, and you can account for that uncertainty," says Reeves. "There are a lot of reservoir properties that we simply don't know, but we sometimes have some ideas about their ranges and their possible types of distribution."

Anadarko Petroleum uses simulation fairly extensively in its CBM operations.

"The more we talk to different people in the industry, not everybody uses simulation to its full effectiveness in coalbed methane," says Brad Miller, area manager of Anadarko's CBM development. At Anadarko's County Line project in the Powder River Basin, the company's pilot wasn't giving up economic rates of gas.

"We had 16 wells going, and conventional wisdom said at the time that that ought to work," recalls Miller. "Well, our simulation showed we needed to drill 40. And then we drilled 40 and put them on, which was a big risk. Production just took off."

Another way Anadarko gets a better idea of what it has underground is through wireline-retrievable coring technology. Faster core retrieval yields better data as there is less time for gas to dissipate from the sample.

### Information technology

Aside from lots of water and one hopes plenty of gas, CBM wells also produce an abundance of data, that is if the technology is in place to collect it. Supervisory control and data acquisition (SCADA) is finding a growing number of adherents among CBM operators.

"We have found a lot of growth [in SCADA] in the CBM area," says Stephen Goodman, vice president of marketing with Control Microsystems. "We consider it to be a very important part of our business, especially in the United States and to some extent in western Canada."

Reeves adds, "On the production side, I think people have been applying SCADA systems more and more to collect all the data. But what people have not been doing is using that information for real-time optimization. To me, that's kind of on the horizon. I expect with the industry demographics—fewer people, lots more wells and a lot of data being collected—you're going to start seeing the application of these optimization and data-mining tools to help engineers manage fields more effectively."



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Facsimile: (303) 991-5075

Storm Cat Energy  
Suite 200, 209-8th Ave SW  
Calgary, AB T2P 1B8 Canada  
Phone: (403) 451-5070  
Facsimile: (403) 451-5075

www.stormcatenergy.com

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*Storm Cat is re-entering its first well on lands in Canada's Elk Valley Field in British Columbia. The Company took a farm-in on nearly 78,000 acres from EnCana Corporation.*

## CBM Flourishes in Vermejo Park Ranch

**W**ithout the right technology it would be impossible to extract coalbed-methane (CBM) profitably. However, CBM production also depends upon solid working relationships with landowners. There may be nowhere where this is truer than Vermejo Park Ranch in Colfax County, New Mexico.

This is where El Paso Production Co. is extracting CBM from coals underlying 593,000 pristine acres in the New Mexico outback owned by media mogul Ted Turner. El Paso has been on the ranch since 1999 and now has in excess of 520 CBM wells with more on the way. El Paso is tapping gas from the Raton Basin, which stretches from just west of Walsenburg, Colo., south to mesas north of Raton and Cimarron, N.M.

Turner bought the ranch from Pennzoil in 1996 but acquired only surface rights. El Paso now owns the liquid mineral rights, which gives it title to the coalbed methane. El Paso's CBM extraction activities on the ranch are guided by a minerals exchange agreement with Turner, which stipulates such things as the number of wells and employees allowed on the ranch at a time, permissible noise levels, where power lines and roads may be placed as well as how equipment is operated.

"We want to have the smallest footprint that we absolutely can, and that means roads, pipeline rights-of-way, locations, visibility of facilities," says Bill Griffin, El Paso Production senior vice president, onshore division. "We're trying to work with all of that while still being efficient on the extraction of gas from the CBM and dewatering the coals."

One might think the strict restrictions on operations would be a significant burden. However, El Paso has risen to the challenge of the stringent requirements through increased planning efforts.

"The minerals extraction agreement forces us to plan further out more than we otherwise would," says Griffin. "We lay out a year-long program, and it's pretty unusual to deviate from that a lot. There is a little less flexibility than we would probably have in a conventional working area. That is an advantage in that it forces us to plan better, I think."

The Raton Basin contains coals with more complex structures than those found in other basins, such as the Arkoma.

"There may be a little bit more faulting, which creates a lot of complexity when trying to stay within your zone," says Griffin. "I would say that it's also a little less homogeneous when we start comparing it to the Hartshorne play."

Despite the challenges, El Paso has managed to grow its Vermejo production to 78 million cubic feet per day net, 84 million per day gross. Gross daily production at the beginning of this year was 66 million.

"For 2006, I think you will see production growth similar to what we witnessed in 2005," Griffin says.

El Paso is transferring operations lessons learned at Vermejo to other plays where the company is active.

"The focus for us in 2005 was to take that same type of approach and apply it to the Hartshorne play in the Arkoma Basin," says Griffin. "And I think in a large part that contributed to what we feel is the most successful year we've ever had with the Hartshorne."

—Joe Fisher



Vermejo Park Ranch (Photo courtesy of El Paso)

## Water everywhere

Vast amounts of produced water are usually a given with CBM. What to do with the water has always been a dilemma. The challenge varies depending upon the water's quality, and treatment can sometimes be an option. However, one of the most straight-forward ways to deal with produced water is provided by strong project economics and planning ahead: re-injection.

Along with partner Warren Resources, Kodiak Oil and Gas is active in the Pacific Rim of the Washakie Basin. The partners drilled a disposal well and installed a major water disposal facility.

"We're currently producing in the range of 4,000 barrels a day out of all the wells, and that water is being disposed of right now quite easily," says Jim Catlin, Kodiak vice president and COO. "I think our facility there could probably handle two to

three times that much water without any real significant changes. The whole trick there was getting set up early on, so we're way ahead of the game."

Anadarko has been addressing the challenges of water production in the Big George play on several fronts. The company has investigated several proprietary water treatment technologies and is building a water treatment facility. However, what is viewed as the ultimate solution is a water pipeline. The 48-mile, 24-inch line will handle between 400,000 and 450,000 barrels of water per day at a construction cost of \$50- to \$100 million, says Miller.

Viewed as aquifer recharge rather than water disposal, the project will pipe water to Anadarko's Salt Creek Field in the Madison Aquifer.

"Instead of putting the water on the ground, we're actually saving the water for the state of Wyoming for future use," Miller says. "If the state wants that water to turn around for agricultural use some time or if they want to clean it up for human consumption, it will be available."



Coalbed-methane desorption lab in Chanute, Kansas. (Photo by Lowell Georgia)

### Industry collaboration

A recent study by the National Petroleum Council found, among other things, that rapid technology transfer is necessary to disseminate best practices among operators. In years past, following the last gas crisis, there used to be more of this, Perry recalls.

“As a result of those programs and a lot of other issues... natural gas was readily available for \$2 and less at the wellhead for many, many years, and I think that over time that supply-demand situation has kind of caught up with us again,” he says.

For want of a natural gas crisis, federal spending on research and development (R&D) for unconventional gas resources has been languishing for years. However, that’s about to change. Coming out of recently passed energy legislation—spurred in part by high natural gas prices—the industry is poised to benefit from at least \$25 million per year for each of the next 10 years for onshore unconventional resources R&D from the U.S. Department of Energy. That amount is half of \$50 million slated for unconventional R&D overall, the other half going to ultra-deepwater drilling. Depending upon congressional appropriations, there’s the potential of up to another \$100 million per year for unconventional R&D onshore and off.

“That kind of funding for a 10-year period is going to go a long way toward a lot of these studies and technology development and characterization of resources that are similar to what was done in past research programs,” says Perry. □

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# The Virtue of Patience

*Producers who bought coalbed-methane acreage in recent years grapple with water disposal issues, anti-development challenges and inadequate infrastructure, but the payoff for their patience may be close at hand.*

**Article by David Wagman, Contributing Editor**

**J**ust shy of its second anniversary as an operating company, Galaxy Energy Corp. finds itself at something of a crossroads. The Denver company has acquired leasehold on 90,000 acres that includes five different drilling areas in the Powder River Basin in Wyoming and Montana. Galaxy has drilled nearly 90 wells into the coal seams there, anywhere from 700 to 2,500 feet deep.

After 18 months of drilling and an investment of about \$25 million, the

company is in an “evaluation stage,” says Marc Bruner Jr., CEO.

Galaxy has multiple issues to weigh as it decides how to make the most of its coalbed-methane (CBM) prospects. The biggest may well be water production and disposal. Like virtually every company working in CBM, Galaxy first has to dewater its wells and figure out how to dispose of the water. In some cases, water disposal is easy. Pipes channel water into nearby rivers and streams or

ranchers take it for livestock and crop irrigation.

Where the water is of poor quality, however, it may need to sit in evaporation pits, receive special treatment before disposal or be reinjected into the ground.

Water may be the biggest issue facing Galaxy, but it is only one part of the environmental equation. Groups opposed to resource drilling in this part of the country are throwing legal and administrative challenges at almost any



*Surface impoundments are often used to contain the produced water from coalbed wells. (Photo by Lowell Georgia)*





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proposal to develop state and federal land. For Galaxy, about two-thirds of its Montana acreage is state or federal land. In Wyoming, about 20% is public. Because of the headaches involved with trying to develop the public land, the company is focusing its development work almost exclusively on land leased from private owners.

“There is less red tape for acquiring permits,” says Bruner. “There is not the same scrutiny as with federal and state land.”

Of course, not all acreage is created the same. Working on private land may be easier, but the best prospects aren't necessarily there.

“All things being equal, I'd rather have great coal under federal land than poor coal under fee acreage,” Bruner says.

Equally vexing are issues related to infrastructure. At its Lighter Field, the company had 18 wells completed at the end of June but had to wait until late August for the

local utility to bring electric power to the site.

“Because of the nature of the basin, your proximity to pipelines and power makes a huge difference,” he says.

### Make-or-break

Scott Zimmerman, president of Denver-based Storm Cat Energy, names four factors that will likely make—or possibly even break—Rockies CBM operators: pipeline capacity, natural gas prices, netback and know-how.

Storm Cat is drilling between 50 and 80 wells in the Powder River Basin and wants to acquire more acreage, in particular undeveloped prospects.

“We want to drill and complete these ourselves,” Zimmerman says.

Last December, the company paid \$1.25 million for a 100% working interest in the Jamison/North Twenty Mile fields in Campbell County, Wyoming. The fields are on the eastern side of the Powder River Basin. Production was

running at about 1 million cubic feet per day from 28 wells. Combined, the fields had net proven reserves of about 2 billion cubic feet (Bcf) and net probable reserves on the order of 5.5 Bcf.

Zimmerman says pipeline capacity, natural gas prices and netback are closely related. Takeaway capacity has improved markedly in the Rockies in recent years, particularly with the addition of the Kern River, Cheyenne Plains and Grasslands pipelines. Three or four years ago when natural gas prices were between \$3 and \$4 per thousand cubic feet, the lack of pipeline capacity meant Rockies producers were enduring low prices of \$1 per thousand cubic feet and below.

Today, given additional pipeline capacity in the region, the differential has narrowed so producers are able to receive between 80% and 90% of the price quoted on the New York Mercantile Exchange. At the same time, improved takeaway capacity means Storm Cat's gas can reach better



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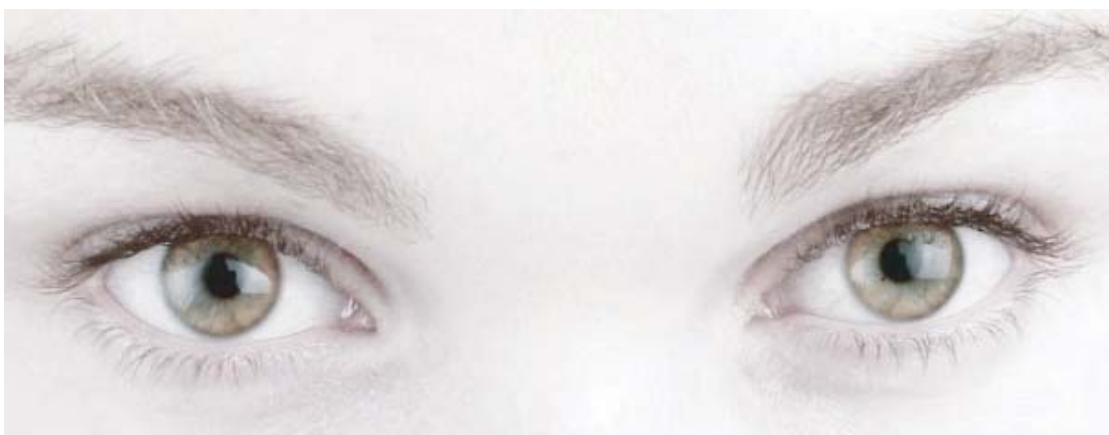


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markets with year-round demand. "Our gas can now flow west, north and east," Zimmerman says.

That's in addition to long-established southern routes to consumers along Colorado's Front Range.

The technical know-how part of the equation appears more challenging. Zimmerman says horizontal drilling of CBM development wells, which has been successful in Appalachian Basin CBM plays, has not proven as effective in the Powder River Basin. Storm Cat's prospects include multiple coal seams that are somewhat thin. "We haven't gotten to the point where we can keep the seam open without it collapsing," Zimmerman says.

Environmental issues are a challenge that "won't go away," he adds. E&P companies need to consult regularly with landowners and also must work hard not to block wildlife migration routes or intrude too much on the views from ranch houses and highways.

Monitoring noise is also important.

### **Landowner tradeoffs**

Working with landowners sometimes means having to look for creative solutions, says Paul Laird, president and CEO of Denver-based New Frontier Energy. The company began development work in the Slater Dome area of southern Wyoming and northern Colorado in 1998 before much infrastructure was in place. Construction of a line to the Opal, Wyo., hub has made it easier to send gas to market. It has also brought in more players, which isn't necessarily a bad thing in CBM. More producers means more dewatering, which can mean a shorter time to resource production.

New Frontier has built its own gathering system, including a 1.6 million-cubic-feet-a-day gas pipeline at a cost of \$2.7 million. The 18.2-mile pipeline opened in June and will let the company start an aggressive

drilling program next year on the one-third of its 40,000 acres that is in private hands. To build the pipeline, Laird negotiated with land owners in the area—some of them fourth-generation—and agreed to give up a position in the gathering line in exchange for exclusive rights of way.

Laird declined to discuss current gas volumes on the pipeline, but says the company also negotiated the right to build a parallel line within the same right of way.

"That gathering system is critical," Laird says.

The only other east-west pipeline in the area is a 1960s-vintage line built by Williams. "Strategically, we are in good shape," he says.

One thing that's becoming clear for CBM lease acquirers is that considerable time and investment are required upfront before gas begins to flow. New Frontier analyzed the economics of its Wyoming play at \$2.50 per thousand



*A stockpile of pipe awaits burial near a compressor station in Wyoming. The pipe will transport coalbed methane to a larger line. (Photo by Lowell Georgia)*

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cubic feet years ago. With natural gas prices substantially higher now, the investment continues to make even more sense, Laird says.

“Cash flow for CBM is on the backside,” he explains, as front-end costs are higher, the resource tends to be longer-lived and production is short to peak. “We’re producing gas now, but we’re not even close to being completed with dewatering.

“You can’t build a company on the fluff of gas prices. You need a reservoir base or you’re just a flash in the pan.”

Laird thinks his company might make one or two acquisitions in the next year. He expects they will be private deals put together away from the scrum of the bid room. Demand for property has some reserves selling for 20 times their worth, he says.

“We’ll wait and pick those up on the backside when they fall out,” says Laird.

### Emerging powerhouse

An emerging player in Rockies CBM is XTO Energy, which first entered the San Juan Basin in 1997 with an acquisition from Amoco. It has continued to expand with land buys in the Raton Basin, Fruitland Coal, Uinta Basin and Piceance Basin, totaling more than \$1.8 billion.

“We’re becoming a powerhouse in the Rockies,” says Keith Hutton, XTO president. “We’re probably going to sneak up on you.”

The company expects to have significant production flowing from its Rockies CBM holdings in 2007. Just how much remains to be seen. Hutton says the company’s capital expenditure budget for next year likely won’t be set before January. At that, the San Juan region alone accounts for about 20% of the company’s gross production of 1.3 Bcf/d.

“The Rockies are not overwhelming the company yet,” Hutton says. “We were lucky; we bought a lot of property before prices ran up.”

That means XTO has stockpiled an inventory of drilling prospects that should give it years of work without the need for more acquisitions.

Hutton says takeaway capacity and other infrastructure issues are

## A few of XTO’s Recent CBM Acquisitions

- \$912 million in August 2004 for ChevronTexaco assets in the Rockies
- \$341 million in May 2004 for ExxonMobil assets in the Rockies
- \$100 million in October 2003 for an unidentified seller’s assets in the San Juan Basin
- \$61 million in June 2003 for Markwest Hydrocarbon asserts in the San Juan Basin
- \$381 million in May 2003 for Williams assets in the Raton and San Juan basins
- \$154 million in December 2002 for J.M. Huber assets in southwestern Colorado
- \$42 million in July 2002 for Marathon Oil assets in the San Juan Basin

not a trap in most places where XTO has property. Trouble spots could be in the Piceance Basin where pipelines are still being laid. He says parts of the Uinta Basin lack adequate compression. “An advantage XTO has is we don’t set up acreage without infrastructure and a development plan,” says Hutton.

In looking at a prospective field, the company considers issues such as gathering capacity and compression.

“It is a huge part of the success for an E&P company,” Hutton says.

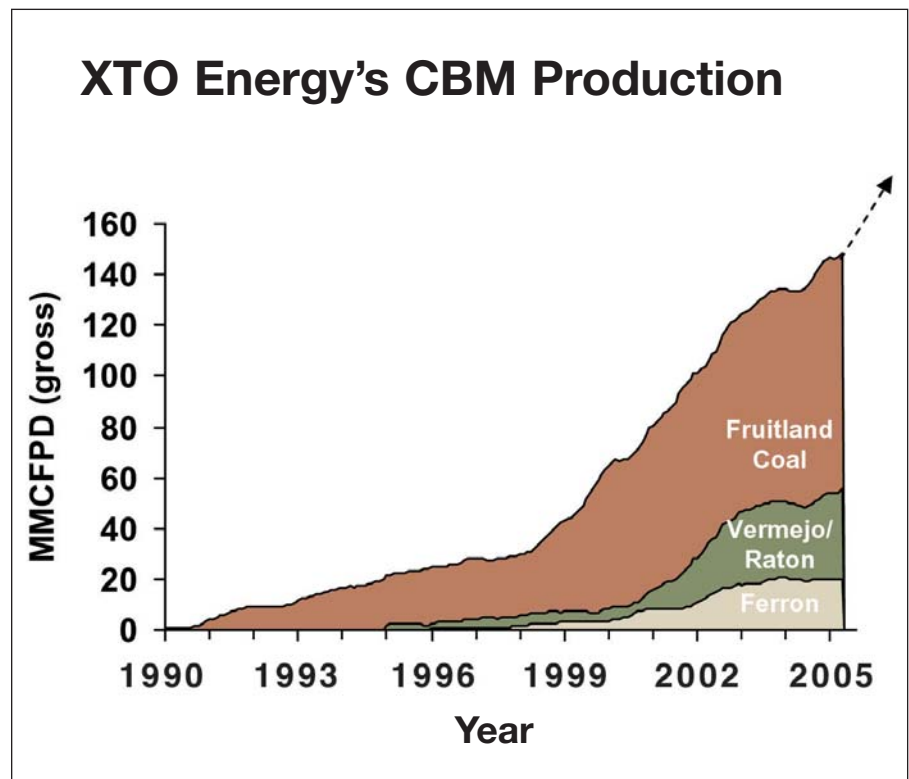
A second area where XTO expects to have success is in well completion

technology. The critical task is getting enough compression on a well to draw out all the water, he says.

“If you don’t pump them, you never see the peak rates or get as much gas out of the ground,” says Hutton.

In the Raton Basin, XTO put conventional pumps on its wells and pulled them as close to a vacuum as possible. Production rose from 26- to 42 million cubic feet per day and could climb as high as 70 million.

“When XTO buys an asset, our expectation is to double it,” Hutton says. □



XTO Energy’s CBM has grown from about 20 million cubic feet per day (MMcf/d) in 1996 to more than 140 MMcf/d in 2005. (Source: XTO Energy Inc.)



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