Outlook for Unconventional Gas: The Next Decade

Vello A. Kuuskraa, Michael L. Godec and Scott R. Reeves
Advanced Resources International, Arlington, VA

As summarized in the first article in this series, we have seen a "decade of progress" in unconventional gas. Annual production from all three of the unconventional gas resource plays - - tight gas sands, coalbed methane and gas shales - - reached a record of 24 Bcfd (during 2006) and so did proved reserves of 105 Tcf (beginning of 2006). Today, two out of three wells in the U.S. target these three natural gas resource plays.

Contrary to views by some that unconventional gas is merely a playground for small producers, today nine of the twelve largest U.S. natural gas fields produce unconventional gas. At the top of this list is the Cretaceous-age tight gas and coalbed methane of the San Juan Basin at 3.8 Bcfd. Next in line is the Barnett gas shales of Newark East field at 1.4 Bcfd. A decade ago, these unconventional gas fields were either undeveloped or much further down the list in terms of size, Table 1.

Building on this decade of progress, the questions now are - - *Is this the peak for unconventional gas? Is industry entering or exiting this resource play? With the surge in costs and the decline in well productivity, is the remaining resource base becoming uneconomic? And, will the future still be unconventional?*

Is This the Peak for Unconventional Gas? The Energy Information Agency (of the U.S. DOE) provides the official scorecard and projections for oil and gas production. In their recent Annual Energy Outlook (AEO) 2007, EIA projects that unconventional natural gas production will continue to grow, from about 8 Tcf per year in 2005, to 8.8 Tcf per year in 2015 and to 10.2 Tcf per year by 2030, accounting for more than half of U.S. lower-48 gas production, Figure 1.

A more disaggregate outlook at each of the unconventional gas sources is provided in Figure 2. This shows that gas production from tight gas sands and coalbed methane is expected to plateau in the next decade, with gas shales providing the great bulk of expected growth (EIA, 2007).

How Reliable Is EIA's Outlook for Unconventional Gas Production? To answer this question, we undertook two tasks. First, we exercised our own unconventional gas data and modeling system (MUGS). Second, we examined six years of actual production data for unconventional gas, and compared this data with past EIA projections.

- The exercise of our MUGS model and its 93 distinct gas plays provides somewhat higher projections for unconventional gas production in the next decade than EIA, particularly for tight gas sands. As such, EIA's projections may be somewhat conservative. (MUGS provides a projection of potential natural gas production without the benefit of some of the constraints included in EIA's National Energy Modeling System, NEMS).

- The actual performance of unconventional gas has consistently exceeded EIA's projections (in past DOE/EIA's Annual Energy Outlooks). Table 2 shows the projections (through 2005) for unconventional gas in twelve Annual Energy Outlooks (AEOs) and compares these to the actual value (circled). For example, AEO 1996 projected that unconventional gas production would grow only modestly, to 2.6 Tcf by year 2005. Four years later, with benefit of new data and an improved model, AEO 2000 raised the year 2005 estimate to 5.6 Tcf. The actual unconventional gas production in 2005 is estimated at 8.0 Tcf, significantly exceeding both of the earlier projections. If history holds, EIA's projections for unconventional gas production ten years from now may, once again, turn out to be low.

Is Industry Entering or Exiting This Resource Play? Another way to gain insight on the outlook for unconventional gas is to look more closely at industry's plans for specific resource plays. A quick review of industry's actions reveals the following:

- **The majors are returning to unconventional gas**. ConocoPhillips, North America's largest natural gas producer, greatly expanded its presence in unconventional gas with the acquisition of Burlington Resources. With this acquisition, ConocoPhillips gained access to 1.2 Bcfd of San Juan Basin tight gas and coalbed methane production, plus significant undeveloped acreage in other resource plays. ExxonMobil has established a sizable deep tight gas prospect in the Piceance Basin of Colorado that, according to company officials, "ultimately could yield some 35 Tcf." Shell is actively developing tight gas sands at the Pinedale Anticline in the Green River Basin of Wyoming (already the fourth largest U.S. natural gas field) with expectations of producing 0.5 Bcfd from this area. BP, with large land holdings in Wyoming and Colorado, recently announced a $4.6 billion, 15 year development program to increase production from these two unconventional gas areas.

- **Large independents are increasing their already substantial investments in unconventional gas.** EnCana, North America's second largest natural gas producer, is placing much of its growth strategy on key unconventional gas resource plays, having already increased gas production from its key resource plays from 1.2 Bcf in 2002 to 2.7 Bcfd, expected for 2007, Figure 3. Anadarko, North America's sixth largest natural gas producer, has identified 1,000 Tcf of future natural gas potential in North America, with 70% being unconventional gas, Figure 4. XTO has built significant positions in key unconventional gas plays, including the acquisition of Dominion's tight sand and coalbed methane assets in the Rocky Mountain and South Texas regions. These actions have enabled XTO to increase its overall gas production from 0.5 Bcfd in 2001 to an expected 1.8 Bcfd in 2007. (Tight gas accounts for

65%, gas shales for 17%, and coalbed methane for 10% of XTO's overall natural gas production.)

- **Mid size and smaller independents are making unconventional gas their core strategy.** Bill Barrett Corporation, formed in March, 2002 after the sale of Barrett Resources to Williams Co., has assembled a portfolio of unconventional gas and oil prospects with 8 to 10 Tcf of un-risked exploration potential, Figure 5. Barrett's exploration prospects include testing the basin-centered tight gas sand play in the Big Horn Basin, a basin whose resource potential has yet to be assessed by the USGS. Southwestern Energy has assembled nearly 900,000 acres in the Fayetteville gas shale play of the Arkoma Basin. According to company officials, assuming development of 50% of the acreage at 80-acre spacing and 1.4 Bcf per well, there is potential for 11 Tcf of gross ultimate gas recovery. Newfield Exploration has acquired 400,000 acres in the Woodford gas shales of the western Arkoma Basin, holding an anticipated upside of 3 to 6 Tcf unbooked net recoverable resources.

Is the Remaining Unconventional Gas Resource Base Becoming Uneconomic? Numerous energy analysts and producers have asked - - *How much has the sharp rise in well drilling and completion costs and the decline in well productivity (reserves per well) harmed the economic viability of unconventional gas?*

With at least a pause in the rise in well costs, the key concern is the steep recent declines in well productivity (see the first article in this series for additional discussion on this topic). A look at the mature San Juan Basin, which has already produced 22 Tcf of tight gas, serves as the example and provides useful insights. The previous decade (1990s), when unconventional gas R&D and technology investment were robust, saw only a modest decline in well productivity. As investment in unconventional gas R&D and technology were slashed in this decade, well productivity resumed its steep decline, Table 3. The "silver lining" in this case study is that, with the persistent pursuit of

efficiencies in well drilling and field operations, the unconventional gas industry has been able to economically develop these otherwise marginally economic resources.

Based on our modeling and analyses, we find that, precluding a collapse in natural gas prices, unconventional gas can and will remain an economically viable or growing gas play, assuming three steps are taken. First, with investments in improved recovery technology, the decline in well productivity needs to be stabilized. Second, with improved geologic and reservoir knowledge, the already discovered unconventional gas plays could be more intensively developed. Third, with support of in-depth resource assessments, the many still overlooked unconventional gas plays and prospects would be added to the resource base.

The Priority Challenges. If unconventional gas is to remain economically viable in light of increasingly difficult reservoir environments, well reserves must be improved. The question is - - *what will it take to achieve this objective?*

In the author's view, as first priority, it will take major new investments in unconventional gas R&D and technology development, considerably beyond the levels of investments made so far in this decade. Imperfections exist in the R&D and technology investment marketplace (as set forth in the recent CBO report, September, 2006). As such, a pooling of R&D investment resources and efforts plus transfer of technology will be required to overcome these market imperfections.

Many of the insights and technologies being used to unlock unconventional gas - - technologies such as efficient multi-zone well completions for coalbed methane, hydraulic fracture mapping and diagnosis for tight gas sands, and the scientific underpinnings of gas recovery from organically rich shales - - were gained from the significant R&D and technology investments made by a partnership involving industry, the Gas Research Institute and the U.S. Department of Energy in the 1990s. With the formation of the new unconventional gas technology institute called RPSEA (Research

Partnership for Securing Energy for America), there is strong reason to believe that similar accomplishments can be achieved during the next decade.

With improved technology, it will also become more feasible to pursue the second priority for unconventional gas - - intensive resource development. The intense infill development of the lenticular Mesaverde tight gas sands of the southern portion of the Piceance Basin at Rulison Field provides a most instructive case study. (Kuuskraa and Ammer, 2004). One section in this field (Section 20, T6S R94W) has been progressively downspaced from its initial 160 acres per well to the current 10 acres per well. As a result, this one section will now contribute 110 Bcf of recoverable resource rather than only 8 Bcf under the initial well spacing, as discussed in the second article in this series. The intensive vertical development of the Lance tight gas formation in the northwestern portion of the Greater Green River Basin at Jonah Field provides a second instructive case study. Here the combination of intensive pay selection and completion (often involving 20 or more frac stages and pay zones) now provide 5 to 10 Bcf wells, up from 1 to 2 Bcf per well with prior completion practices.

Third, the future of unconventional gas will rest on the successful pursuit of new, previously overlooked basins and plays, such as the tight gas reservoir in the Columbia and Big Horn basins, Figure 6, and the numerous emerging gas shale plays of the Mid-Continent, West Texas and the Rockies, Figure 7. There are also massive resources of deep high rank coalbed methane in the Piceance, Uinta and Greater Green River basins and shallow, lower rank coalbed methane along the Gulf Coast. Again, advances in technology will be essential for unlocking these challenging unconventional gas resources.

Finally, the efficient and environmentally prudent development of unconventional gas will require supportive regulatory frameworks and public policies, particularly with respect to resource access and environmental stewardship. Industry and government will need to continue to work collaboratively to ensure that this critically important domestic resource can be developed, while also ensuring that the environment and

other public interests are appropriately protected. Addressing these challenges can help to ensure that "the future will still be unconventional."

Table 1. Nine Of The Twelve Largest U.S. Natural Gas Fields Produce Unconventional Gas

Rank	Field Name	Basin/State	Type of Resource	Year 1996 Production (Bcfd)	Year 2005 Production (Bcfd)
1	San Juan Basin Gas Area	San Juan, NM/CO	CBM/Tight Gas Sands	3.4	3.8
2	Newark East	Ft. Worth, TX	Gas Shale	0.1	1.4
4	Pinedale	GGRB, WY	Tight Gas Sands	-	1.3
5	Wyodak/Big George	Powder River, WY	CBM	-	0.9
6	Jonah	GGRB, WY	Tight Gas Sands	-	0.7
7	S. Piceance Basin Gas Area	Piceance, CO	Tight Gas Sands/CBM	<0.05	0.7
8	Carthage	East Texas, TX	Tight Gas Sands	0.6	0.6
10	Wattenberg Basin	Denver, CO	Tight Gas Sands	0.2	0.5
12	Antrim	Michigan, MI	Gas Shale	0.2	0.5

Sources: EIA 1996 and 2005 Annual Reserve Reports; Advanced Resources Unconventional Gas Data Base.

Table 2. Examining EIA's Outlook for Unconventional Gas Production
(Last Twelve AEOs (1996 – 2007))

Year for AEO*	Projected Unconventional Gas Production (Tcf)					
	2000	2001	2002	2003	2004	2005
1996	2.3	2.3	2.3	2.4	2.5	2.6
1997	3.0	2.9	3.1	3.2	3.3	3.3
1998	3.5	3.6	3.6	3.6	3.6	3.7
1999	3.8	3.9	3.9	3.9	3.8	3.9
2000	4.8	4.7	4.8	4.9	4.9	4.9
2001	4.7	4.8	5.0	5.3	5.4	5.6
2002	4.6	4.9	4.9	5.6	5.7	5.8
2003	5.2**	5.4	5.6	6.1	6.3	6.3
2004		5.6**	5.9	6.2	6.1	6.2
2005			6.5**	6.6	7.0	7.3
2006				6.8**	7.5	7.5
2007					7.5**	8.0**

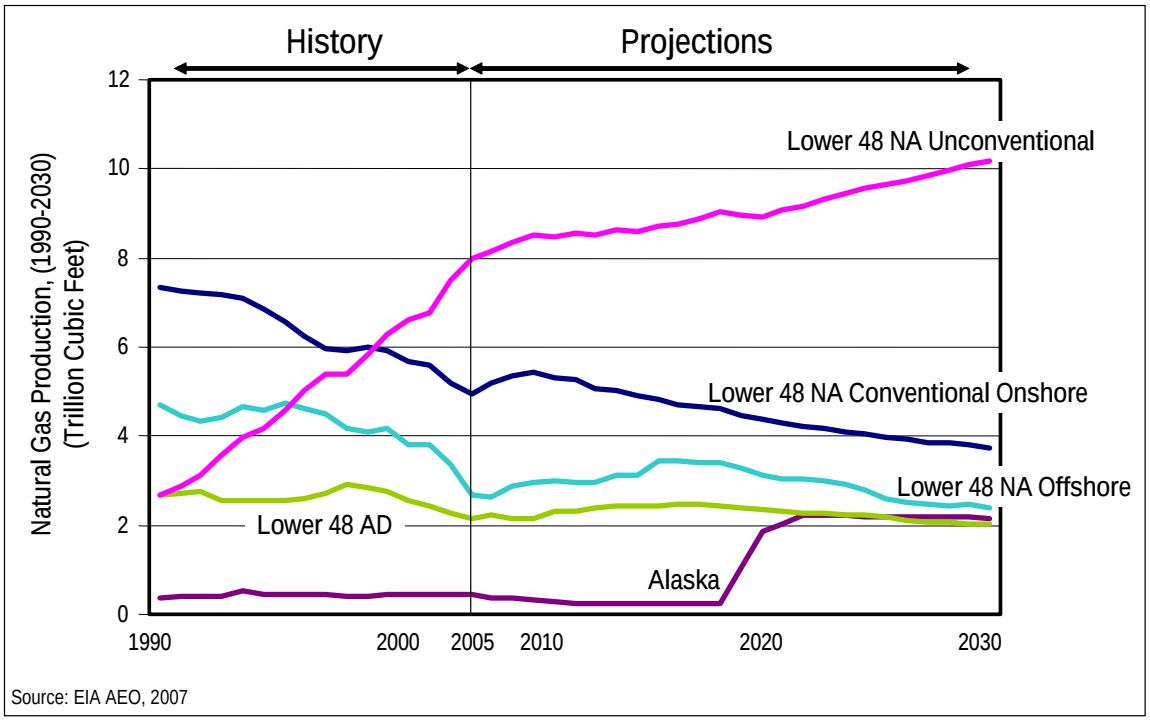
*AEO = EIA's AEO Annual Energy Outlook
**Actual unconventional gas production

JAF02658.PPT

Table 3. Trends in Well Performance for Three Tight Gas Sand Plays, San Juan Basin

Time Period	Pictured Cliffs (Bcf/Well)	Mesaverde (Bcf/Well)	Dakota (Bcf/Well)
Pre-1980	0.94	3.14	1.99
1980-1989	0.69	1.24	0.89
1990-1995	0.99	1.15	1.03
1996-1999	0.83	0.93	0.73
2000-2005	0.51	0.86	0.58
Wells Drilled	6,465	7,879	6,291
Cumulative Recovery (Bcf)	4,272	11,495	6,389
Est. Ultimate Recovery	5,700	15,300	8,200

Figure 1. Unconventional Production is a Growing Source of U.S. Gas Supply



JAF02658.PPT

Figure 2. Gas Shales Account for Much of the Expected Growth in Unconventional Gas Production

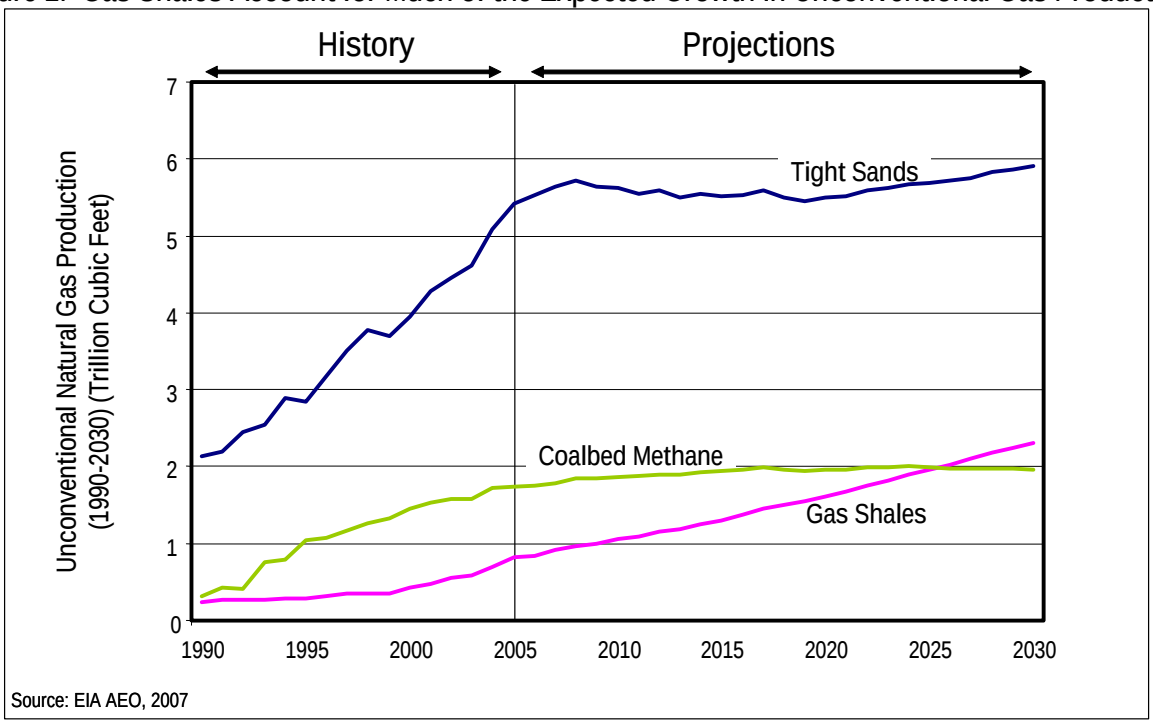


Figure 3. Resource Plays Driving Production and Growth For EnCana

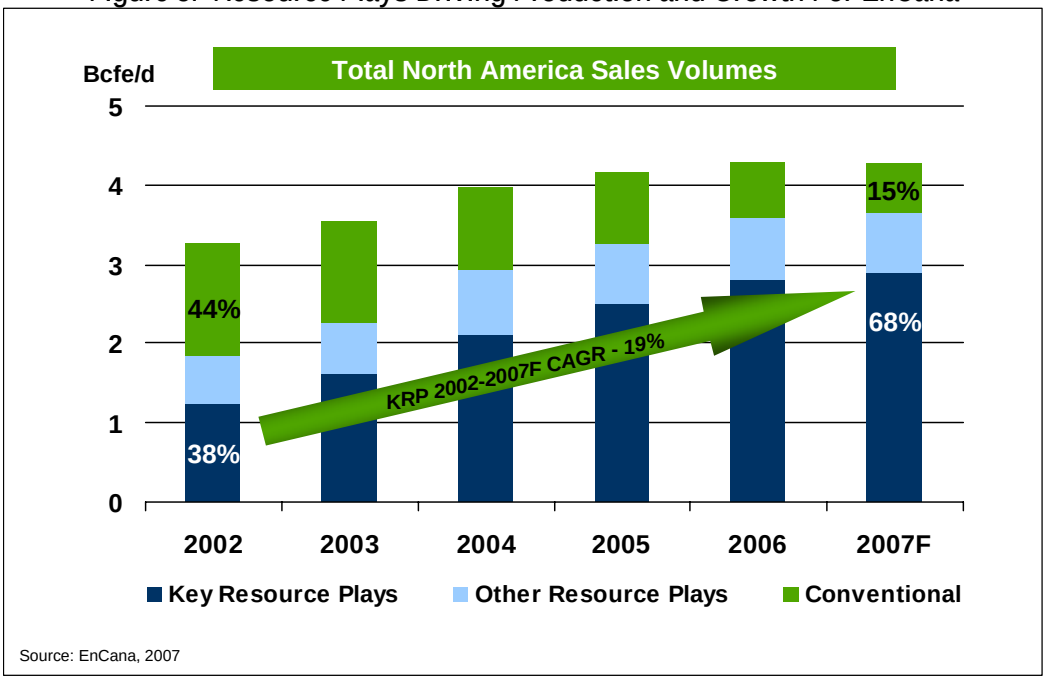
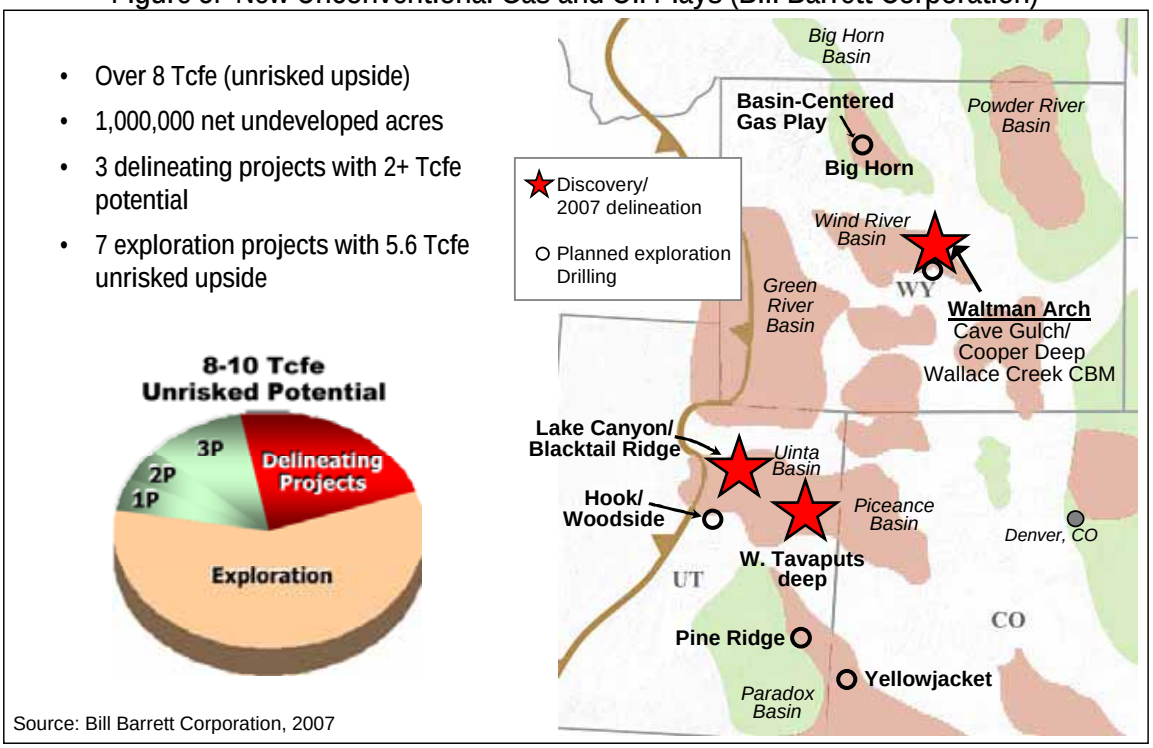


Figure 4. Anadarko Petroleum's Perspective on North American Natural Gas Resources

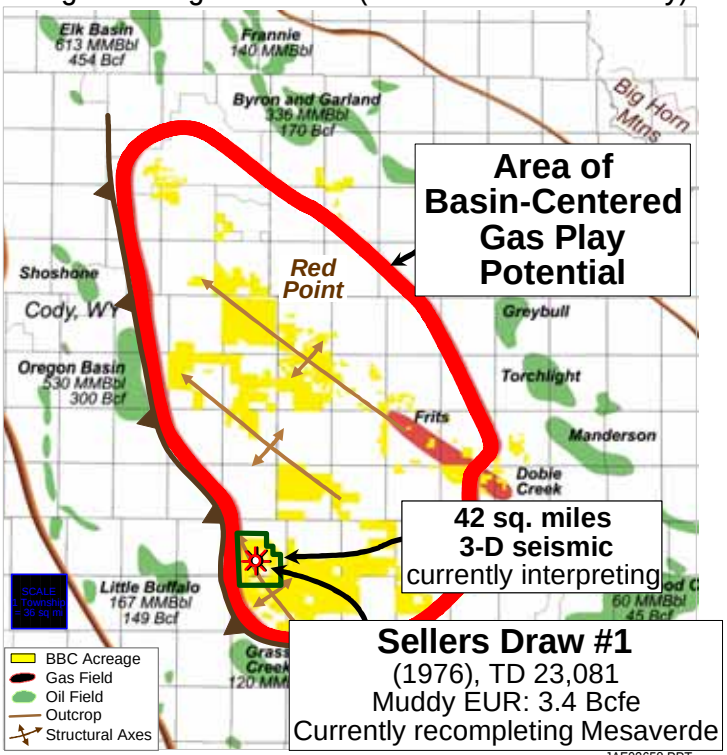
Source: Anadarko

Figure 5. New Unconventional Gas and Oil Plays (Bill Barrett Corporation)



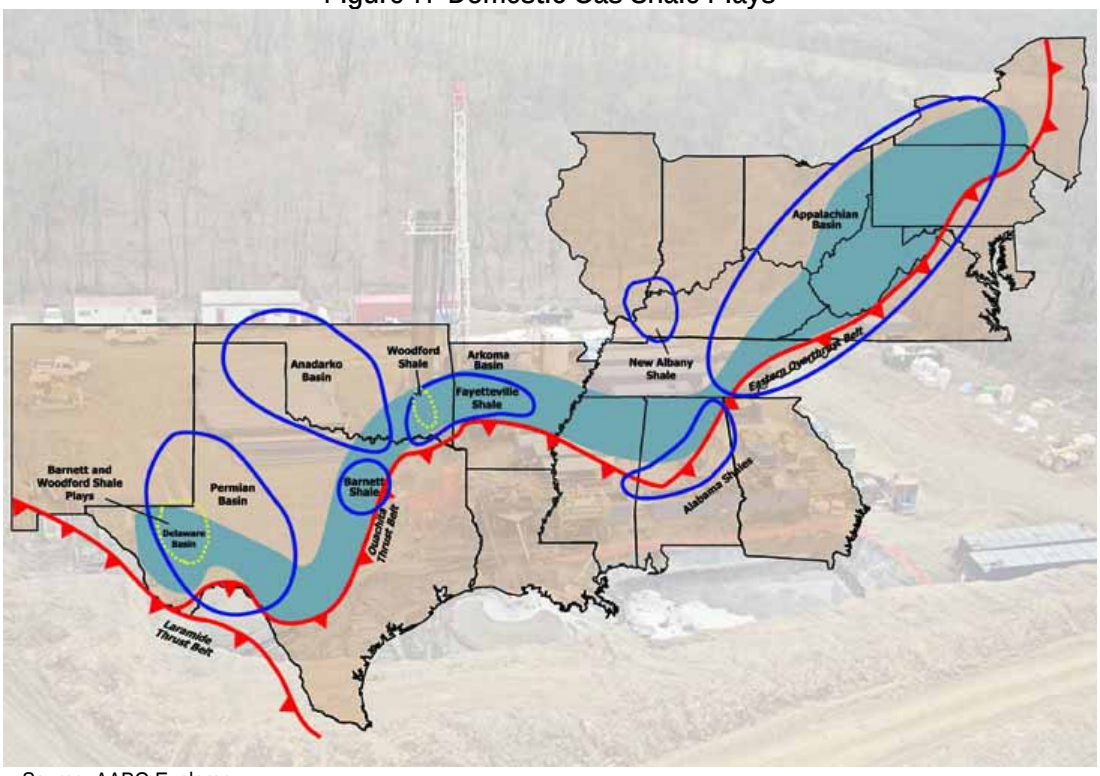
JAF02658.PPT

Figure 6. Big Horn Basin (Basin-Centered Gas Play)



JAF02658.PPT

Figure 7. Domestic Gas Shale Plays



Source: AAPG Explorer

References

"Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions", A CBO Paper, Congress of the United States, Congressional Budget Office, September 2006.

Kuuskraa, V.A., and Ammer, J., "Tight Gas Sands Development – How to Dramatically Improve Recovery Efficiency", Unconventional Resources, GasTIPS, Winter 2004.

U.S. DOE, Energy Information Administration, "U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2005 Annual Report", DOE/EIA-0216(2005), November, 2006

Authors

Mr. Vello A. Kuuskraa is President of Advanced Resources International with over 30 years of experience in the oil and gas industry, particularly unconventional oil and gas resources, enhanced oil recovery and CO2 sequestration. He has a B.S. in Applied Mathematics from North Carolina State University and an MBA from the Wharton Graduate School, University of Pennsylvania. He serves on the Board of Directors of Southwestern Energy Company.

Mr. Michael L. Godec is Vice President of Advanced Resources with 20 years of experience in the oil and gas industry. His areas of expertise include energy policy, oil and natural gas forecasting and environmental impact assessments. Previously, he was a Senior Vice President at ICF Consulting. Mr. Godec has a B.Sc. in Chemical Engineering from the University of Colorado and a M.Sc. in Technology and Human Affairs from Washington University, St. Louis.

Scott R. Reeves is the Executive Vice President of Advanced Resources International, Inc., in Houston, Texas. He has over 20 years of experience with unconventional gas, enhanced oil recovery and carbon sequestration, with particular emphasis on feasibility studies and reservoir engineering. Mr. Reeves received a B.S. in Petroleum Engineering from Texas A&M University and an MBA from Duke University.