The US Natural Gas Revolution: Technology Transforms A Market*

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Search and Discovery Article #70101 (2011)
Posted July 12, 2011

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, USA, April 10-13, 2011

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Abstract

The North American natural gas market has transformed over the last decade owing to the extreme growth in shale gas production. Shale gas will continue to exert a significant impact on U.S. and international markets, reducing the need for Canadian and LNG imports in the coming decade. The Marcellus Shale has the greatest potential to create significant market disruptions since natural gas production from the Appalachian Basin could increase by two or three times in the next five years. Surging productivity from U.S. shale gas fields could curtail the need for natural gas imports for a decade or more and provide clean fuel to substitute for coal-fired power generation. Shale gas productivity gains are driven by advances in technology, experience and knowledge.

Along with the increase in production, numerous new west-to-east pipelines were installed to deliver natural gas to markets. New pipeline projects including the Rockies Express, Gulf Crossing, and Midcontinent Express helped to alleviate transportation constraints and serve to reduce price differentials by increasing relative prices in the West while dampening prices in the East. More than 30 pipeline expansion projects were proposed to support natural gas production growth, short-haul and long-haul pipeline transportation capacity and pipeline interconnections in the region. Realization of even some of these projects would enable Marcellus production to displace natural gas supplies from Canada, the Rocky Mountains, the Midcontinent and other producing areas. Northeast price premiums would be likely too, and price spreads between the Northeast, western Canada and the Rocky Mountains could tighten.

In most natural gas producing regions, natural gas liquids (NGL), in particular ethane, are a highly-valued byproduct. NGL is sold as an important feedstock, often priced significantly higher than natural gas and hence helps to improve the profitability at the wellhead. Yet, in the Marcellus ethane is potentially a constraint if adequate processing and transportation infrastructure are not developed or if demand for ethane does not remain sufficiently robust.

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The US Natural Gas Revolution: Technology Transforms A Market

Presented To:

AAPG 2011 Annual Convention & Exhibition

Houston, TX
April 12, 2011

BENTEK Energy LLC

Good Afternoon I want to begin by thanking Scott and the folks from the AAPG for the opportunity to be here today. I have never been to an AAPG Convention and it is quite remarkable.

Key Points Of My Presentation

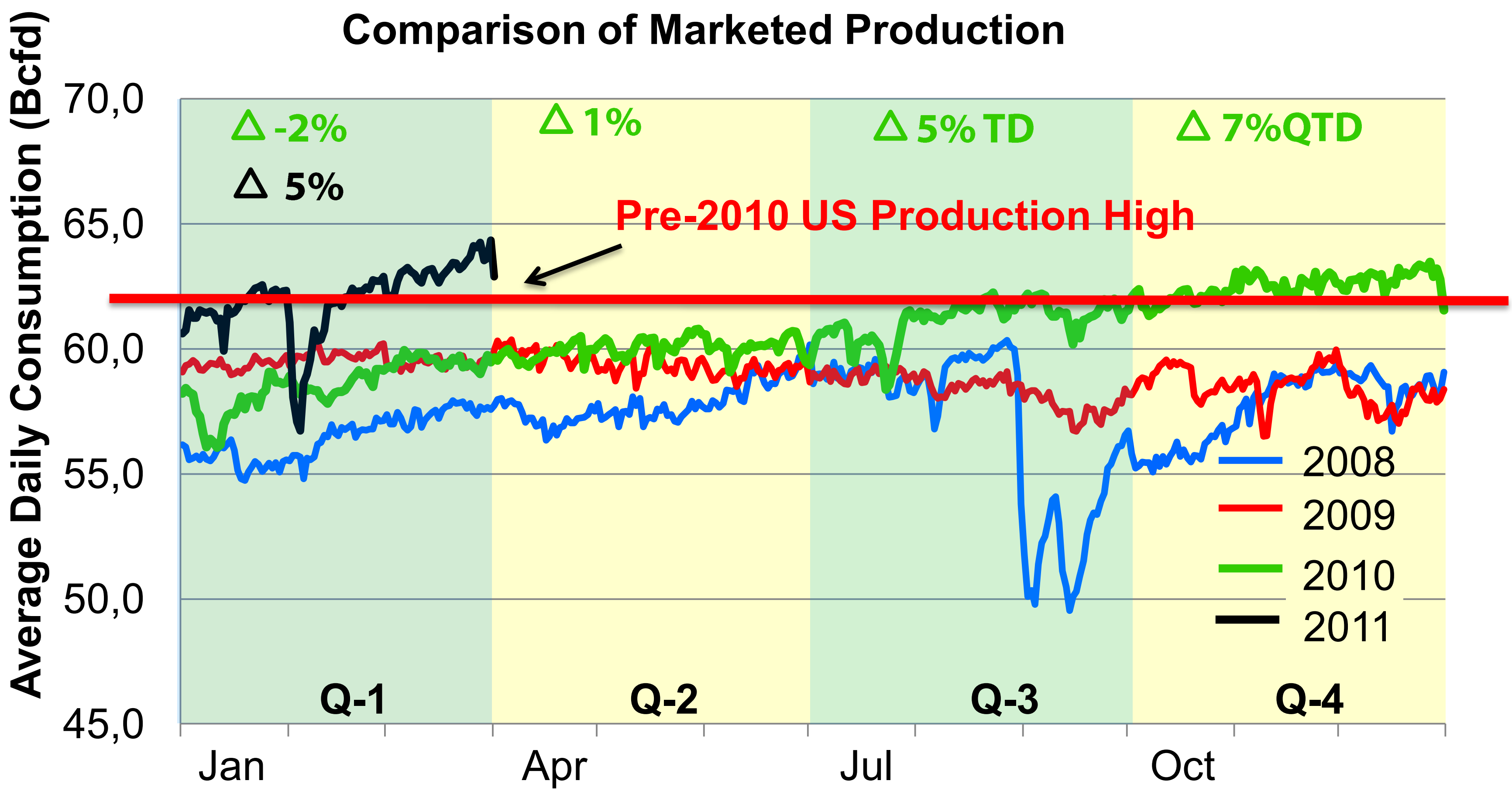
- US natural gas production has reached record production levels.
- Growth has occurred because of evolving technology and process innovation that have and will continue to drive costs down.
- The implications are profound for the industry, consumers, the economy and the environment.

For the next 20 minutes or so I am going to talk about the **remarkable transformation of US natural gas industry**. As you will be able to tell I am very optimistic and enthusiastic about the future of the natural gas industry and its role in the US and potentially the global economy. I was originally trained in history and one of the realities of studying history is that it is usually very difficult to understand an event or series of events without the benefit of elapsed time.

Nevertheless, the past few years we have witnessed a monumental transformation. While the **government spent billions** to propel alternative energy technologies into a commercially competitive state (and largely failed) because we believed we were "running out of natural gas", market dynamics drove investment in the oil and gas sectors with the result that we now appear to have a future in which we have ample natural gas resources available at a competitive price; enough to transform our entire energy economy, from power to transportation to heating and derivative products.

It will take a decade or more to fully appreciate the extent of this transformation, but I believe it holds a magnificent prospect. I am going to spend the next few minutes discussing several key dimensions of this technology transformation and its implications.
I have provided a handout with a number of graphics that illustrate many of the points that I will make.

US Production Is At Record Levels



Data through March 7, 2011

Source: BENTEK Supply and Demand Report

August 23, 2010 was an historic day in the US and it went largely unnoticed. August 23 was the first day that US producers produced more than 62.158 Bcfd. What is significant about that? **62.158** is the daily equivalent of the annual production in 1971, historically the year of highest production.

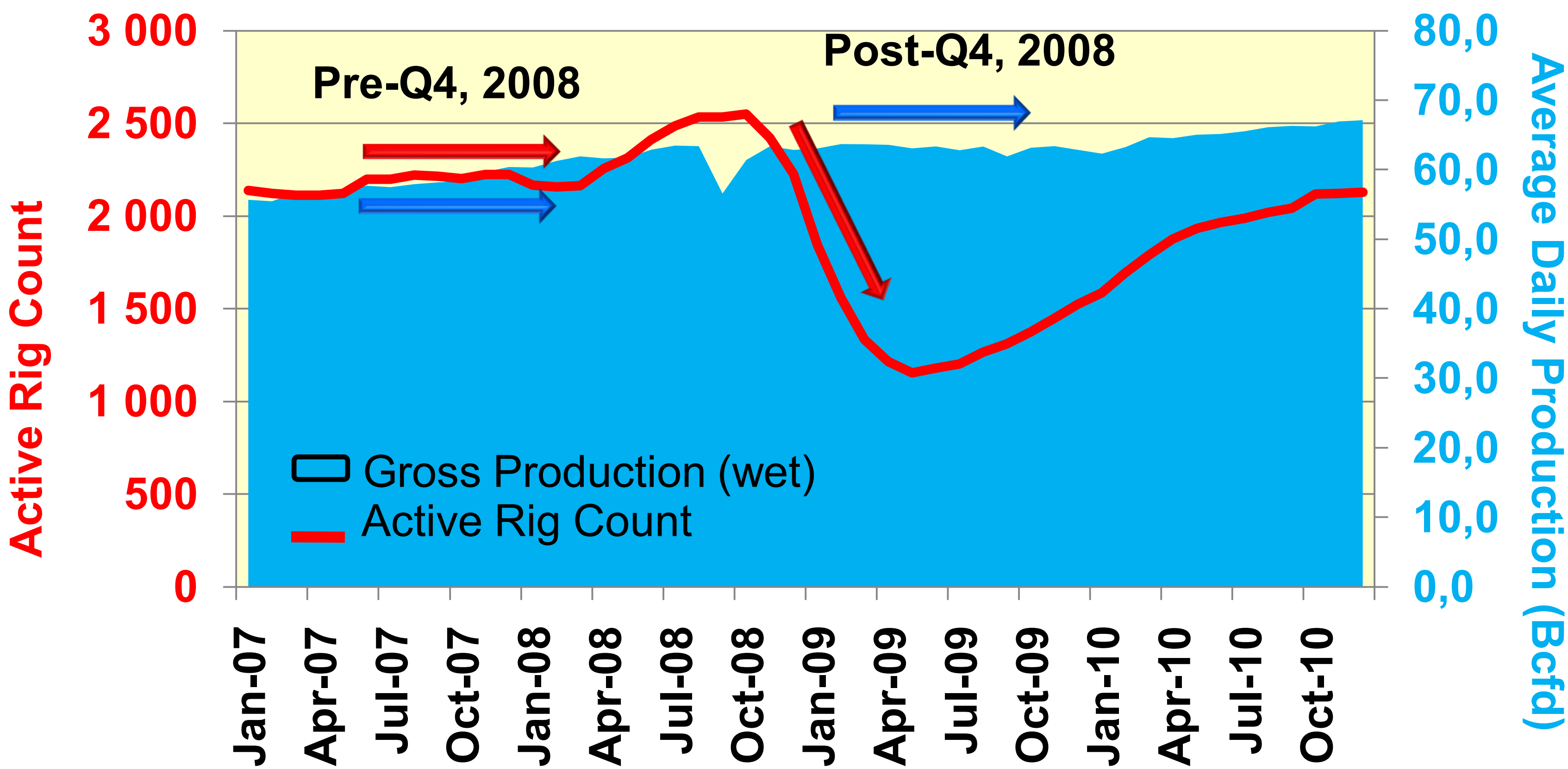
Between Aug 23 and Dec 31, there were **75 days on which the US produced at least 62.2 Bcfd.**

During Q4 Production averaged 62.5 Bcfd, some 300 MMcfd higher than in 1971.

So far in 2011, Production has averaged slightly less than **62.2** Bcf because of the freeze-offs that occurred in Jan and Feb.
None the less there have been **several days** where production has reached **64.35 Bcfd, some 2.2 Bcf/d** more than on the average day during 1971. If we keep going at the current rate, the US will set a new production record this year.

Testimony to just how significant this supply position is came in Jan and Feb. You can see the drop, which resulted from supply freeze offs. In the past, prices would have increased sharply. This year the price impact was virtually non-existent, except in the NE where pipeline issues still linger.

Historic Relationship Between Rig Count & Production No Longer Holds



Data through December 31, 2010

Source: BENTEK, RigData

TECHNOLOGY CHANGES UNDERPIN THE GROWTH.

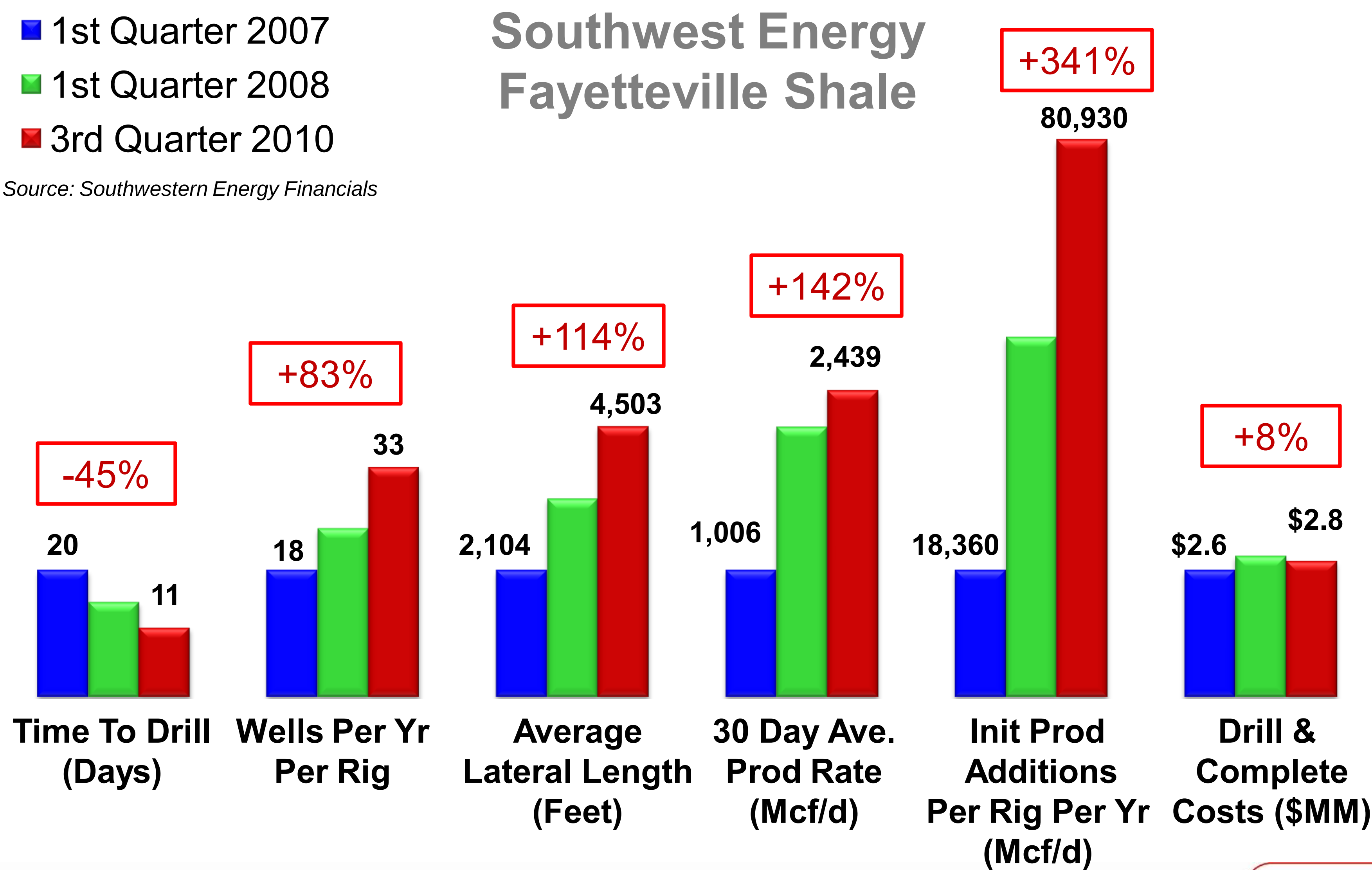
The impact of changing technology first became apparent during the first 6 months of 2009. Remember in October, 2008 as the financial crisis was unfolding, drilling rig activity reached its zenith at **2549** active rigs. Gas prices peaked in June of 2008 at nearly $14 per mmbtu.

As prices fell below $5 in late Aug of 2008, concern about the rig count began to rise. Beginning in October 2008 the rig count began to fall dramatically, falling some 60% by May 2009.

As the rig count fell, many analysts in the industry expected in turn the production would follow suit. Their logic: prior to that time the rig count was a pretty good indicator of production; when the rig count rose, production followed and the obverse was also true. Most thought as the rig count fell, production would fall and prices would rise back over $6. They were to be surprised, as the market fooled them.
There were two factors that were overlooked. First, there were many uncompleted wells that were brought online during the spring bolstering production. Some of them were related to producers in the Rockies waiting for Rex to come online and others were attributed to shortages of completion crews. Whichever, they helped underpin production.

But the second factor was far more important: the impacts that technology change was having on production.

Drilling Rig Productivity Has Dramatically Improved



Source: Southwestern Energy Financials

TECHNOLOGY IS REDEFINING RIG EFFICIENCIES.

The magnitude of technology change that is impacting the gas industry is evident when one looks at the time-to-drill statistics offered by many producers.

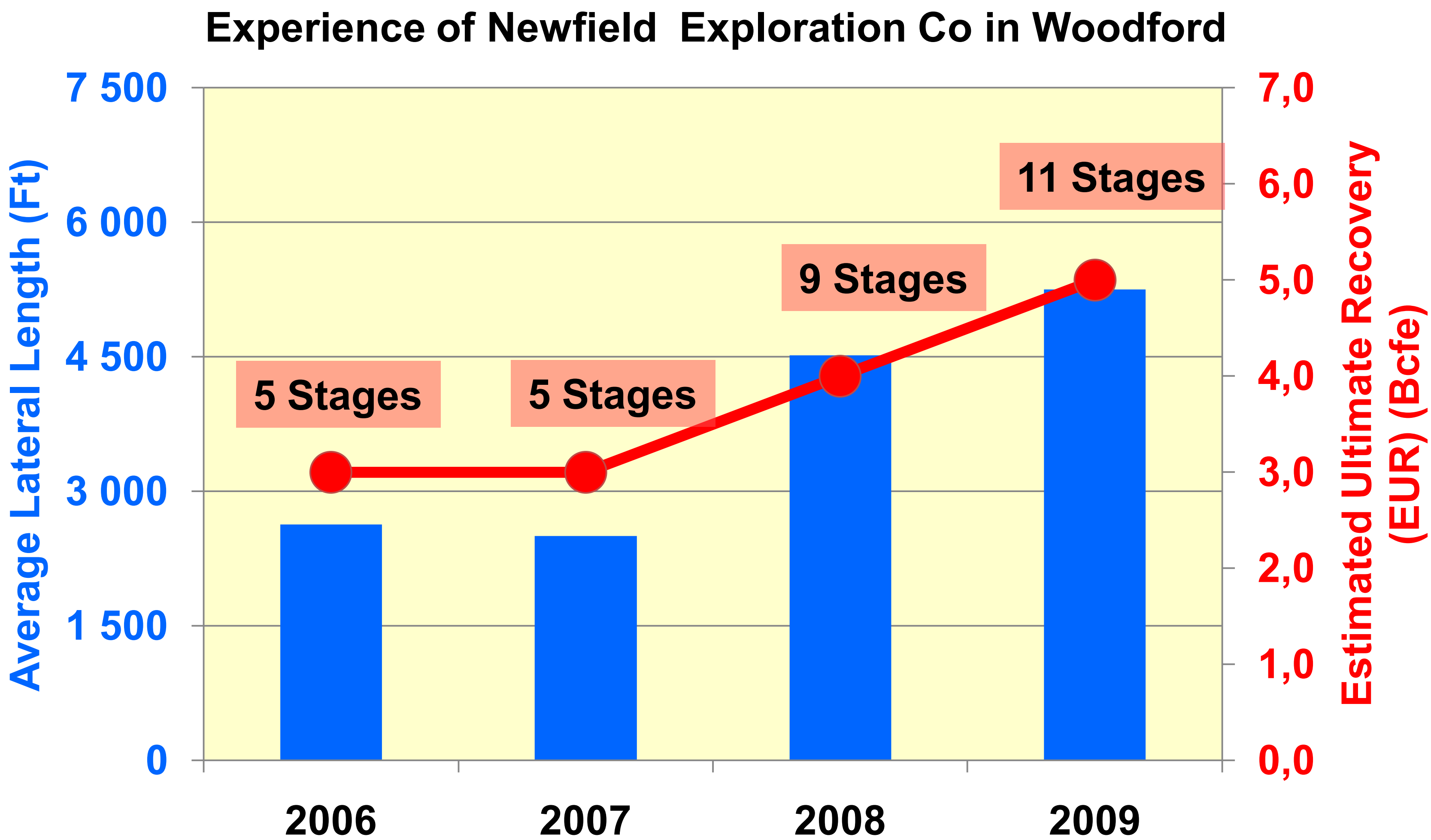
This slide shows the numbers for Southwest Energy, an independent company that operates primarily in the Fayetteville, East Texas, and Marcellus.

Between Q1-2007 and Q4-2009 **the time it took them to drill a well decreased by 45%.** What makes this more remarkable is that the length of the horizontal lateral they drilled increased by **over 100%**. So they drilled wells that were twice as long, twice as fast. During the period their 30 day production rates rose dramatically and their production additions per year per rig increased by nearly **350%**. All this happened while total **cost per rig increased only 8%** and if looked at on a **$/MMBtu** produced in the first year basis fell significantly.

This is but one company's example, but producer analyst presentations are full of similar information.

In the Pinedale area of the Green River/Overthrust **Ultra dropped its average drilling time from nearly 80 days in 2006 to 23-25 in 2010**. In their case average depth remained flat, but D & C costs fell from **$7.0 to $4.8 Million**. One finds this type of productivity improvement in all shales and to lesser extent even among conventional producers in the Anadarko and Permian basins.

Longer Laterals & Increased Hydro-Fracturing Also Drive Production Gains



HYDRAULIC FRACTURING IS A MAJOR TECHNOLOGY BEHIND THE TRANSFORMATION.

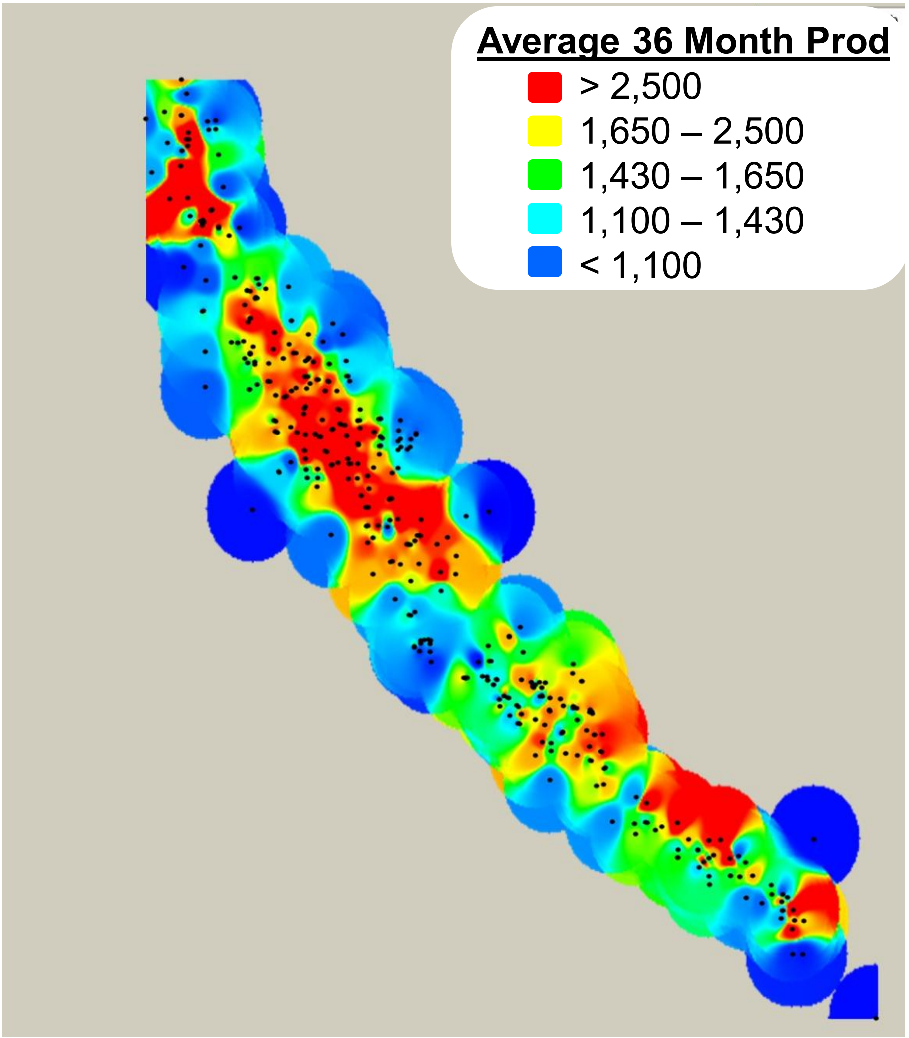
This slide shows the number of fracing stages employed by Newfield Exploration in the Woodford area of Oklahoma. Between 2006 and 2009 the **number of stages doubled and estimated ultimate recovery rose dramatically as well. Longer laterals were a principle reason for the increased number of frac stages**. Ultimate lateral length is a function of technology and state regulation around unitization. I **expect to see laterals continue to lengthen as pipeline technology and regulation evolve**.

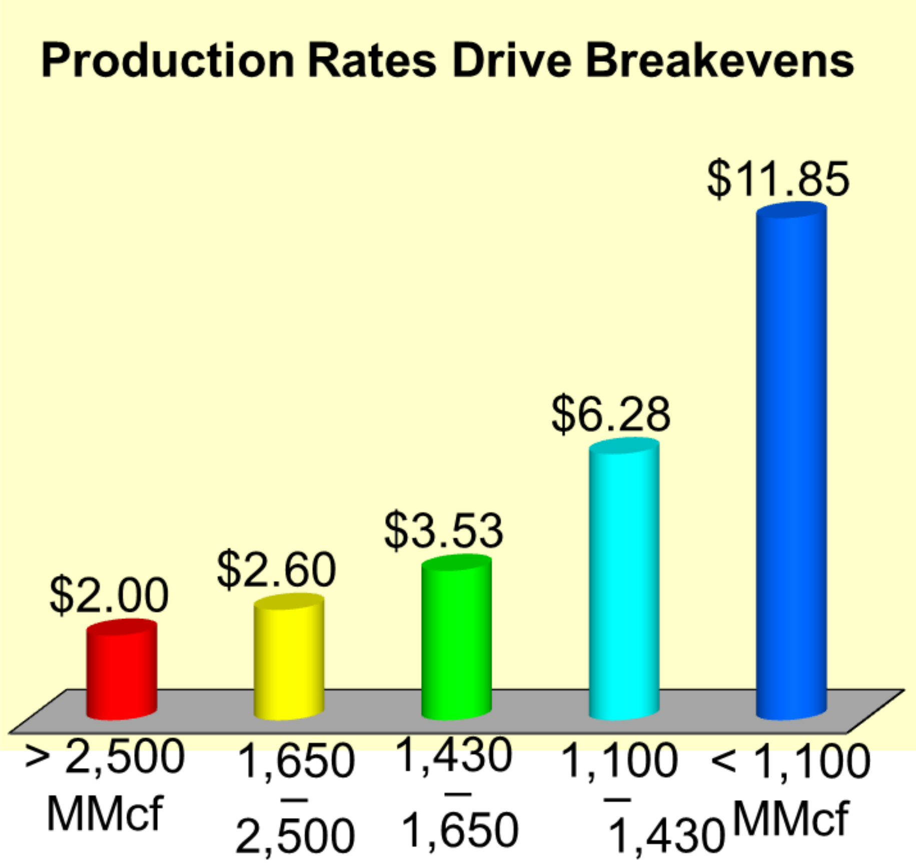
Fracing is an integral part of this production growth. Over **51%** of active rigs are currently drilling horizontal wells. All of them will use multiple stage fracing to produce their volumes and many of the directional and vertical wells are fraced as well. In the **Green River Basin**, most wells there are directionally drilled, but many employ **20** or more fracs on laterals that may be over twice as long as the ones used in the Woodford.

Similarly in the **Bakken**, I have heard of as many as **34 fracs** being used on one well that had a lateral length well over 2 miles.

Geology Is Another Significant Factor

Pinedale Production Heat Map





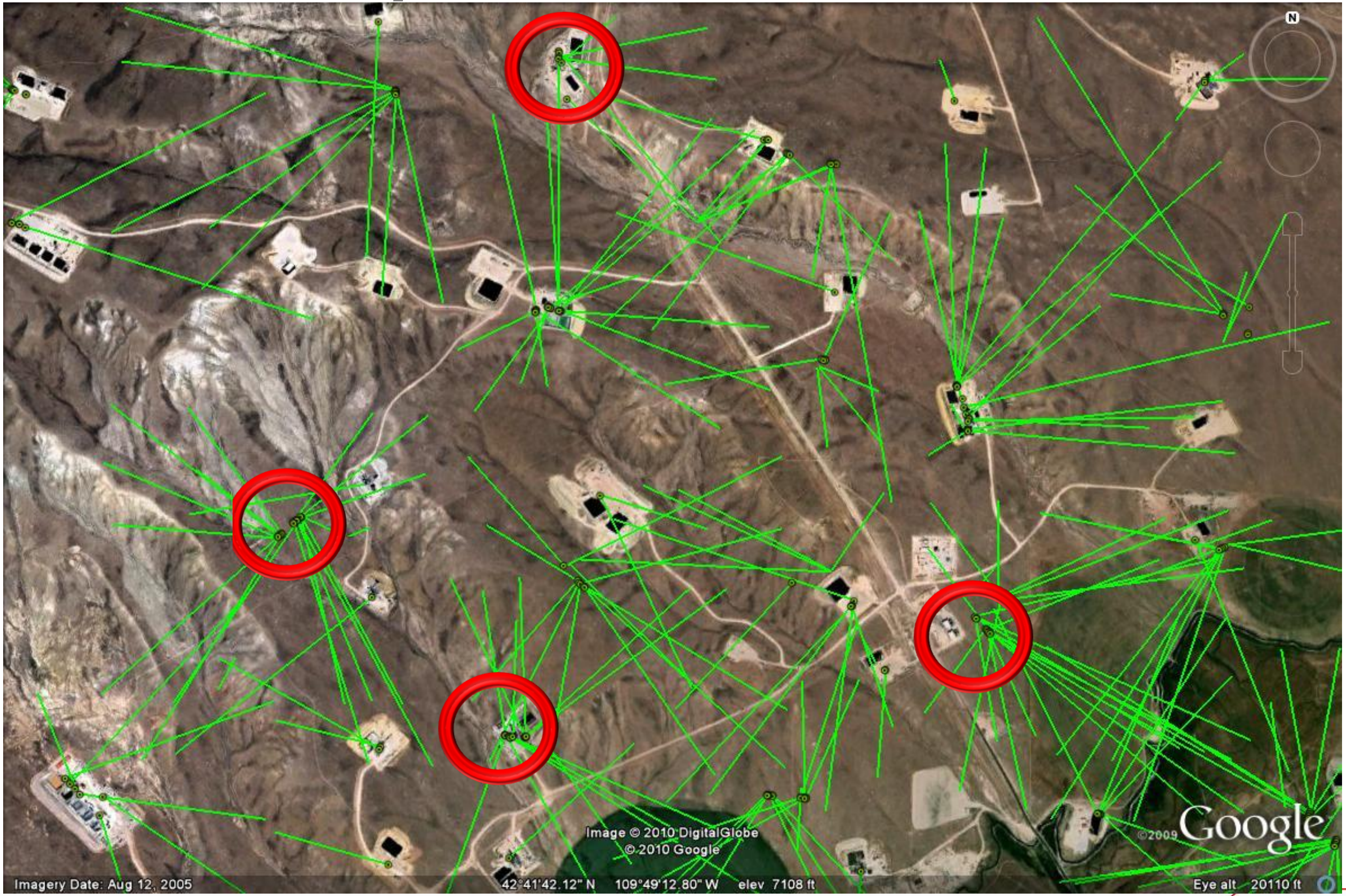
Geology is another major factor in the productivity gains. This slide shows on the left a heat map depicting the productivity of various regions within the Pinedale Field in the Green River Basin. The red region is the most productive while the dark blue least productive, based on total production over the first 36 months of production.

The graphic on the right shows the difference in the breakeven price associated with each productivity level. The red areas are so productive and their production levels are so high that their average breakeven cost assuming a 10% IRR is $2.00. (Many producers such as Ultra have much lower breakevens). The blue regions are much higher.

BENTEK estimates that there are anywhere from **3 to 10 years** or more worth of acreage inventory depending on ones assumptions about well spacings.

Click to view notes

Multi-Well Pad Drilling Reduces Land Disruption And Reduces Drill Times



THE GROWING USE OF MULTI-WELL PADS IS ANOTHER MANAGEMENT/ENVIRONMENTAL INNOVATION THAT IS MAKING THE DRILLING FUNCTION MORE EFFICIENT.

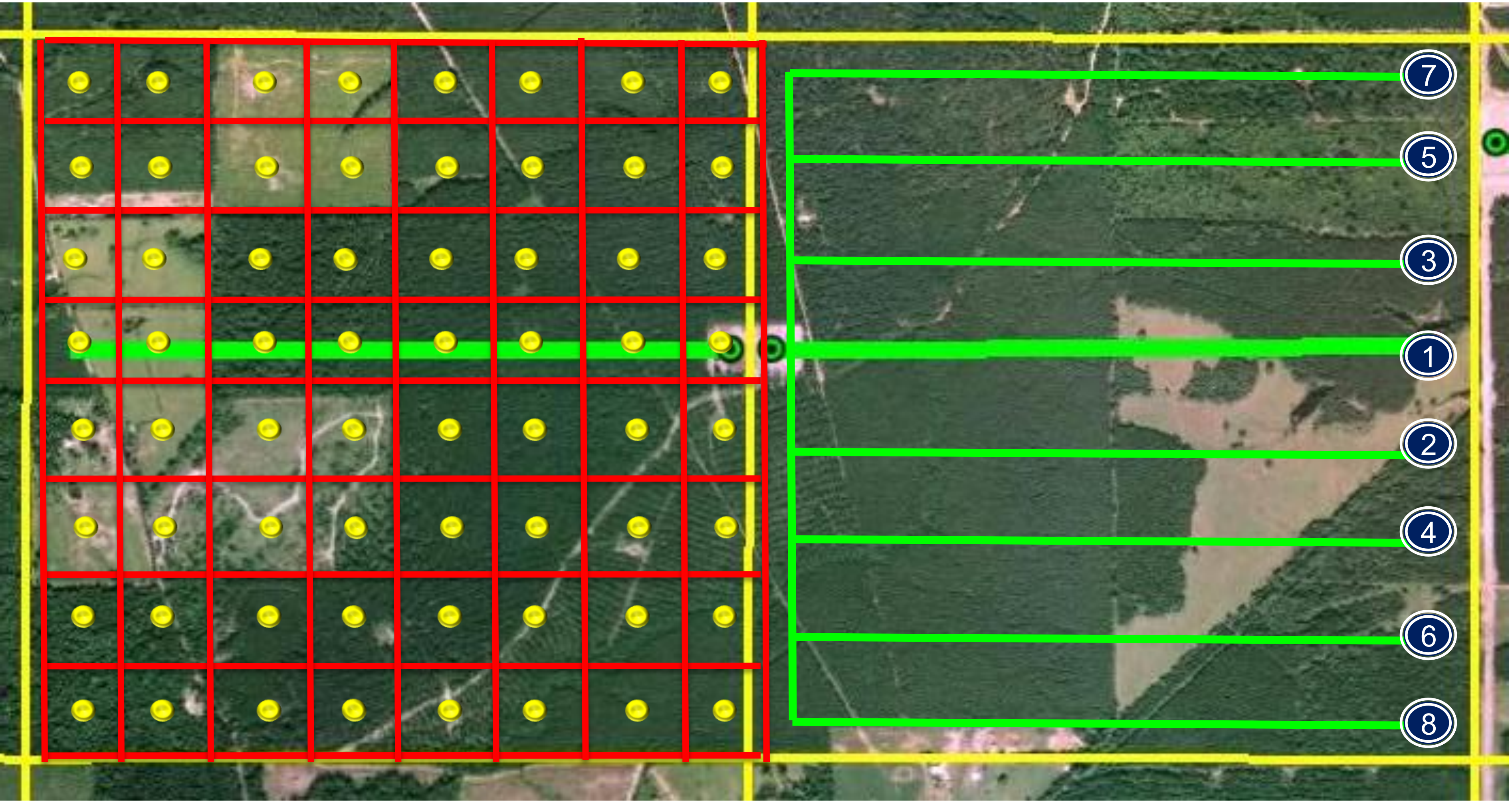
Here is an aerial photograph of wells in the Pinedale area . The green lines represent the well bore, the red circles show multi-well pads where several of these wells originate.

Over the past few years, producers are increasingly using this approach. In the Green River Basin, many producers use what are known as **"SIM OP"** pads. These have an area of about **10 acres and can hold as many as 32** wells. These pads allow for simultaneous drilling, completion and production. In the Marcellus, pads are smaller and the smaller size typically does not permit simultaneous completion and drilling activities.

These pads improve efficiency in multiple ways. Previously, a well would be drilled, then the rig packed up and moved maybe a mile or more away through a process that took multiple days. Today, the rig literally moves about 20 feet in a few hours and is back to work, drilling.

Today, an efficient drilling program is much more an exercise in fine tuning a manufacturing-like process than was the case of drilling wells in the 1990's. When you talk to folks working on these rigs, they are constantly trying to re-engineer processes to cut an hour here or there to further drive down drilling times.

But Eventually Will Utilize The Multi-Well Pad Approach As Well



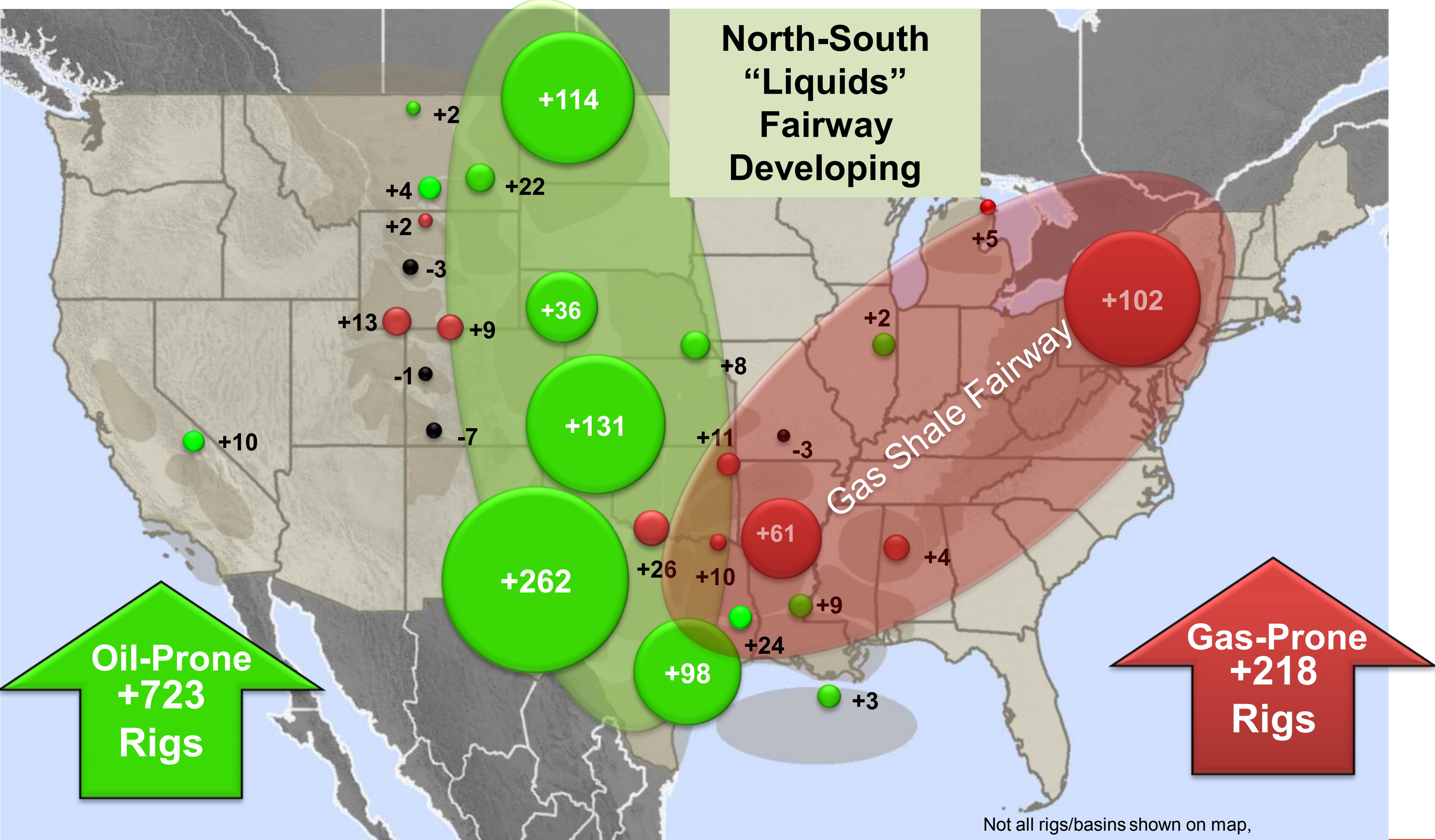
Historic Section Layout **Future Section Layout**

This slide illustrates the environmental and efficiency aspects of multi-well pads in the Haynesville context. The graphic on the right shows a stylized version of how the section will be drilled via horizontal drilling techniques. The graphic on the left shows what it would have looked like in years past. The yellow dots represent wells drilled on 80 acre spacing. Each well would require construction of connecting gathering and probably roadway, thus entail vastly greater land disruption.

Imagine moving a drilling rig to each well site, then contrast that image with moving the drilling rig a few feet on the well pad. It is not difficult at all to understand why the industry has become so much more productive.

Business journals often state that environmental stewardship makes good business sense. This is just one example of how that concept is playing out in the oil and gas industry. Efforts to make the industry more cost efficient are leading to enormous environmental benefits. The low price environment that producers expect over the next x years will ensure that these efforts continue.

Since May 2009, Exploration Has Shifted To Oil



Not all rigs/basins shown on map,

Source: RigData, BENTEK

TECHNOLOGY IS BEGINNING TO IMPACT OIL/LIQUIDS DEVELOPMENT AND IN THE PROCESS INTEGRATING THE THREE MARKETS.

In late 2009 many analysts including BENTEK thought that because volumes had grown so significantly in 2009 relative to demand that the price softness would drive down the rig count in 2010.

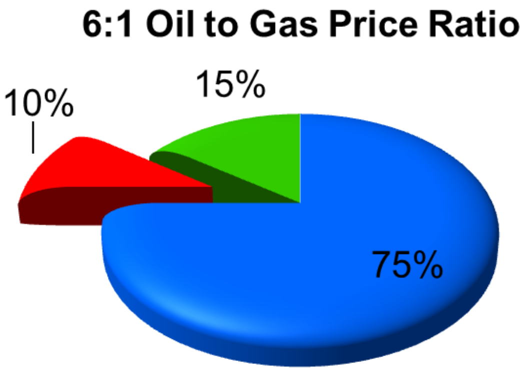
That did not happen, at least in the manner anticipated, because of an unexpected benefit of the technological changes that have occurred in the late 2000's. Producers figured out how to use horizontal drilling and fracing techniques to unlock deposits of oil and gas liquids – ethane, propane, butane, etc. **This "discovery" is dramatically impacting the gas industry.**

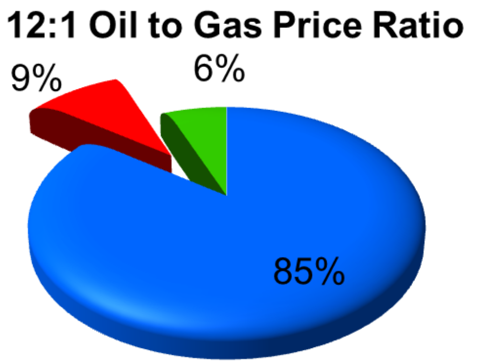
Here we see the change in rig count by commodity. The red circles depict basins where the increase rig counts are due primarily to natural gas, the green where they are due to producers seeking oil or gas liquids. **Since May 2009**, when the rig count was at its lowest point in recent years, **3 out of 4** incremental rigs have started to work in either oil- or liquids-prone plays, most of which are in the traditional areas of the Permian and Anadarko basins or the Rockies. **Two to three years ago, companies like Chesapeake and EOG touted themselves as "Gas" companies. Now they have brought the Oil label back into the business.**

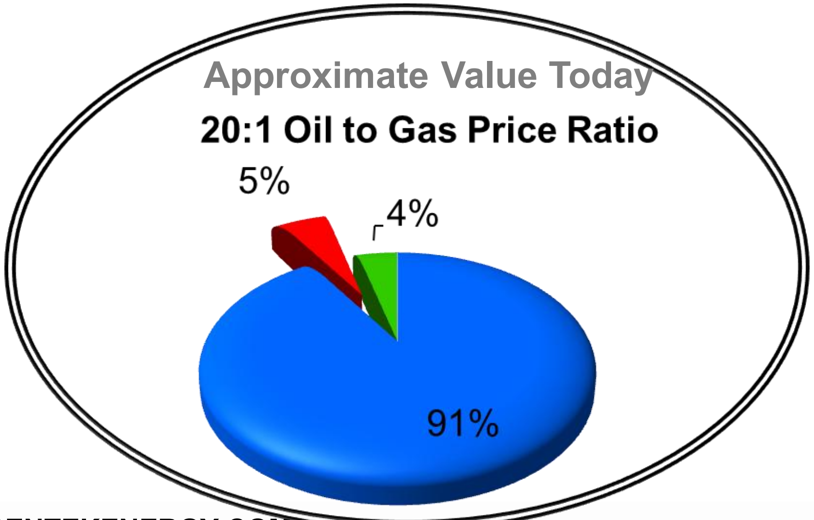
It is too early to gauge the result of these efforts to find more oil, but several states reported oil production gains in 2010: **TX up 3%, Utah up 7%**, **Colorado up less than 1%** and **North Dakota up over 40%**. It is possible that these technologies may lead to significantly greater US oil production as well as gas production.

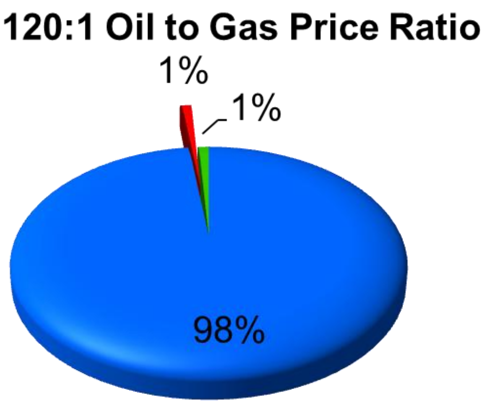
The Higher The Oil To Gas Price Ratio, The Less Value Accrues To Natural Gas

Values For Typical Sprayberry Formation Well In The Permian Basin









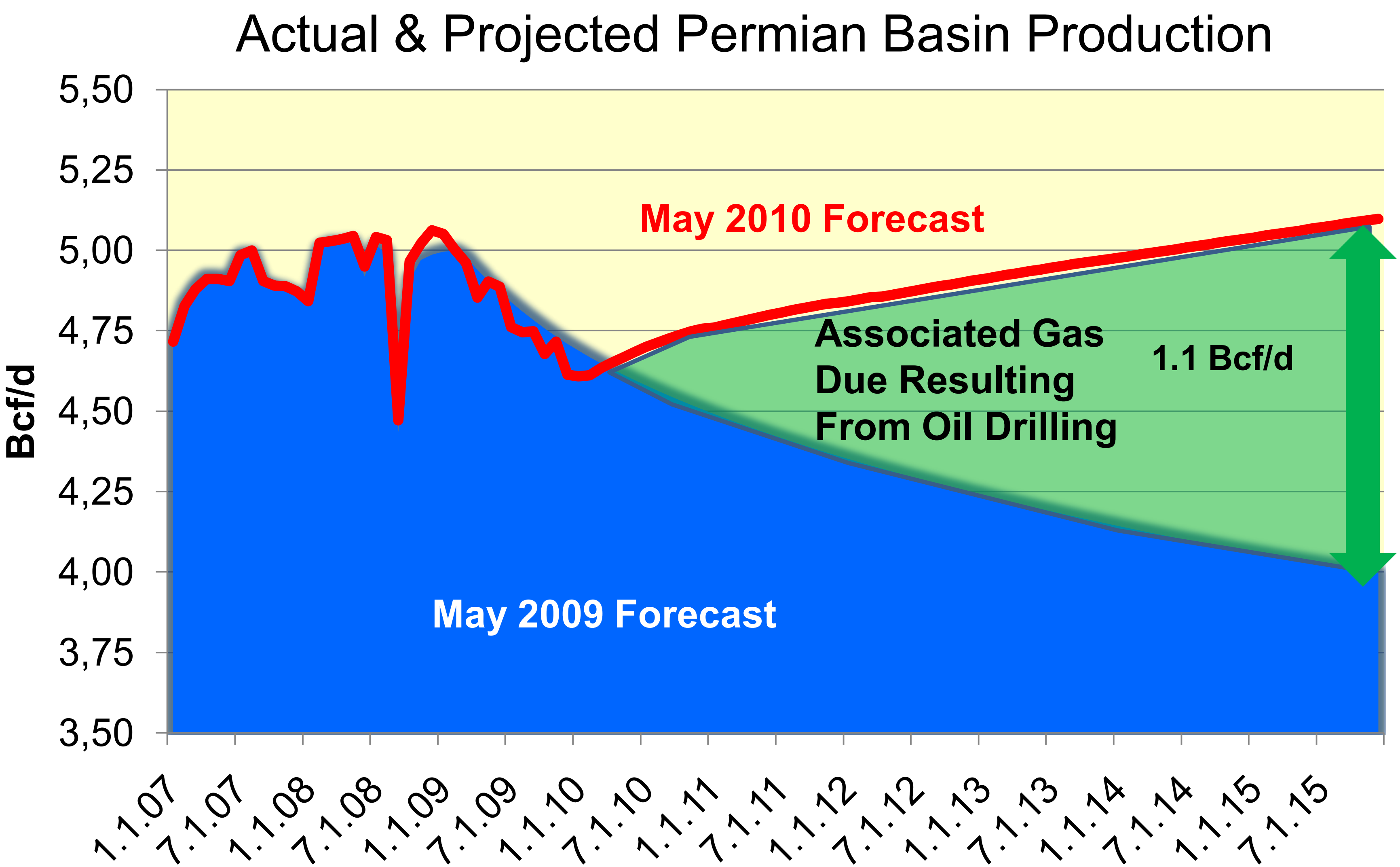
OIL AND LIQUIDS RADICALLY ALTER WELL ECONOMICS.

Exploration is shifting to oil and liquids from gas. Why and what are the implications for gas. This next set of slides illustrate the impacts.

First, oil and liquids exploration changes the breakeven calculation. In this slide I show the relative value attributed to oil, liquids and gas for a typical Sprayberry well in the Permian Basin. **At a 20:1 oil to gas price ratio, which is approximately the cost today, revenues associated with natural gas only account for about 5% of the total revenue** created by the well. Most of the value is associated with oil. The breakeven price of gas is virtually irrelevant for a producer trying to determine whether to drill the well or not. The gas price could be $0.50 per MMBtu, but if the oil price is $100, the well will be drilled.

For those of you familiar with LNG markets, this should sound familiar. A couple of years ago, many questioned whether Quatar would send LNG to the US at a $4.00 price because they would lose money on the transaction. What analysts did not recognize is that Quatar and in fact much of the LNG supply world derive the value for their production from its liquids value. The gas value as LNG is simply gravy. Even if gas were valued below $4.00 Quatar would ship it here if no other option was more attractive and liquids prices remain high.

Oil & Liquids Exploration Will Drive Gas Production



THE CONCEPT OF ASSOCIATED GAS HAS RE-EMERGED

When you produce oil from many of the oil- and liquids-prone shales, you also produce natural gas.

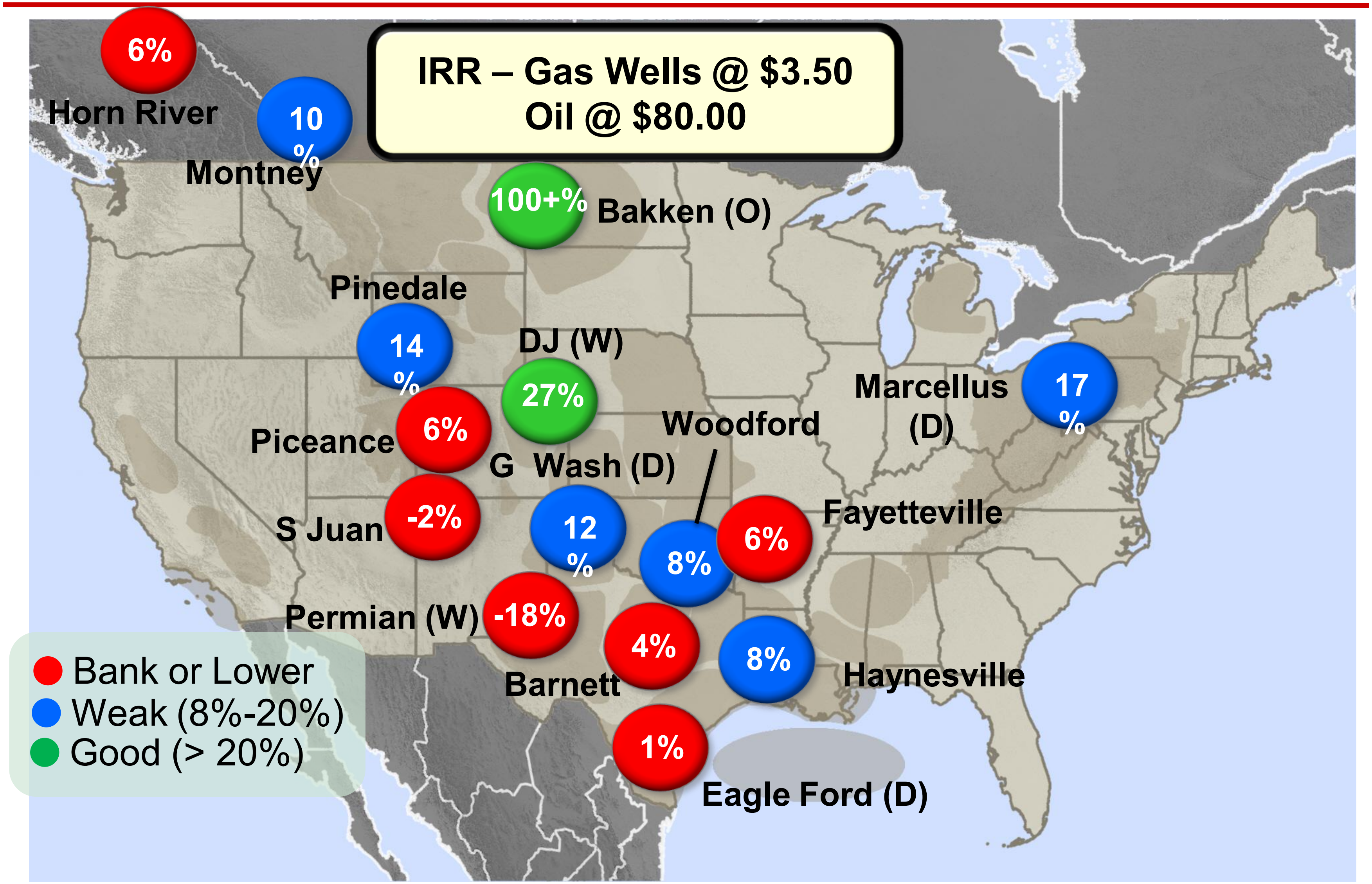
When BENTEK forecasts production from an area we do so based on the decline curve of existing wells, a projected rig activity estimate and associated drilling pace and average well performance data from recently drilled wells. Essentially we estimate the number of wells that will be drilled, then add production for each well based on production rates that are typical for the basin.

The blue area shows our estimate as of May 2009. Production was projected to decline because of the precipitous decline in drilling activity that occurred during the first 5 months of the year.

The red line shows our projection as of May 2010. It calls for dramatically more gas to be produced from the Permian Basin because oil drilling brought back drill rigs and as they produce oil they produce gas. Oil exploration will increase gas production levels by over **1. Bcfd** in the next four years.

This type of outcome is happening in virtually all of the oil- and liquids-prone shale plays.

Comparative Rates Of Return



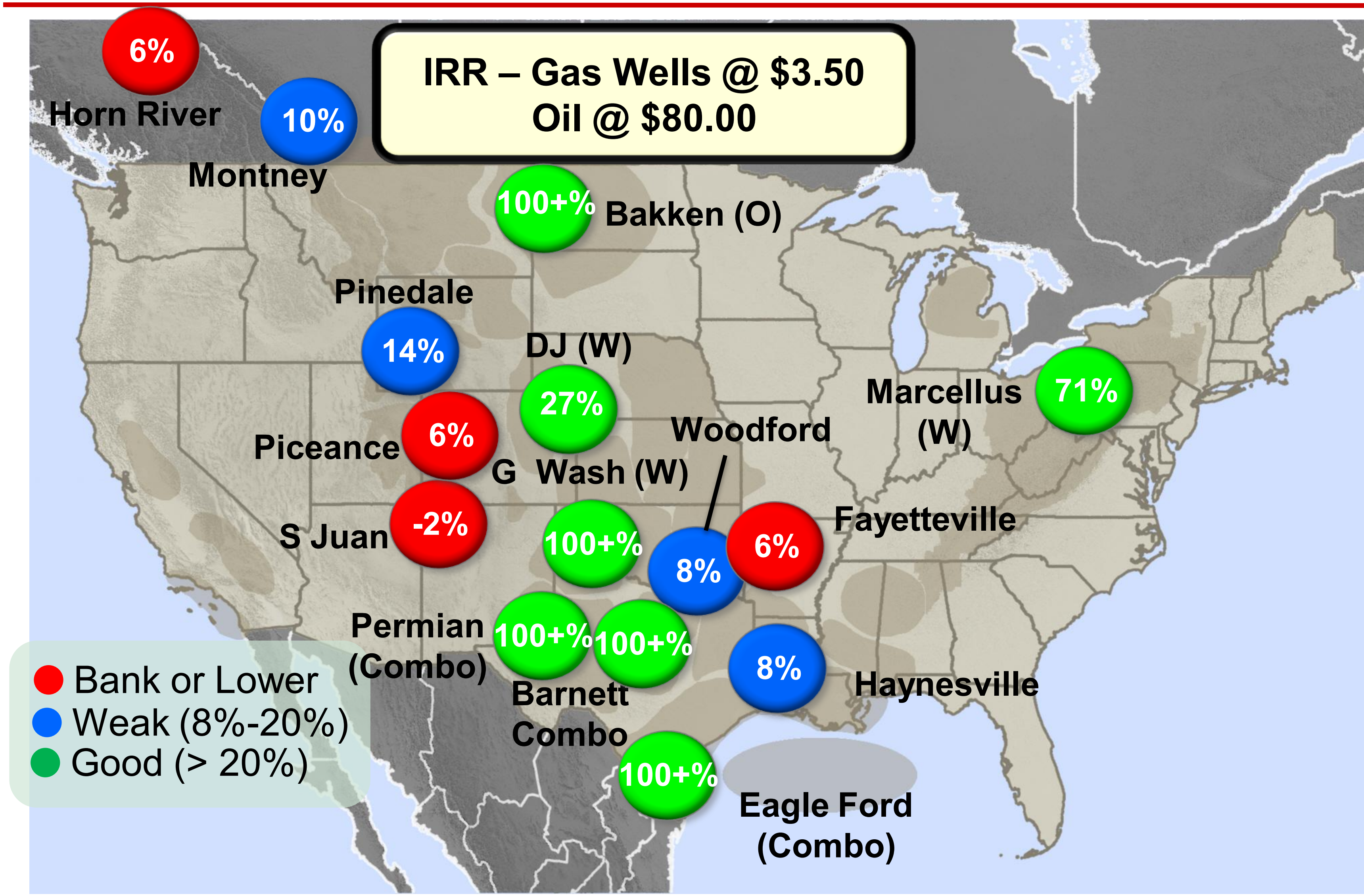
THE BOTTOM LINE: OIL AND LIQUIDS PRESENCE CHANGE INVESTMENT POTENTIAL

All of these dynamics impact rate of return calculations on which producers and investors base exploration decisions. I have included three calculations to illustrate their impacts.

Slide 19 shows the rate of return that BENTEK projects for exploration activities in all of the major plays. The key assumption in this graph is we have only included revenue streams for dry gas options, except in a few places where that is not logically practical: Bakken (0il) and the DJ and Permian areas where it is almost impossible to produce dry gas, as liquids are too prevalent. Given these prices **$3.50** gas and **$80** oil, many areas are marginal performers. **The only exceptions are the Bakken and DJ.**

Click to view notes

Comparative Rates Of Return



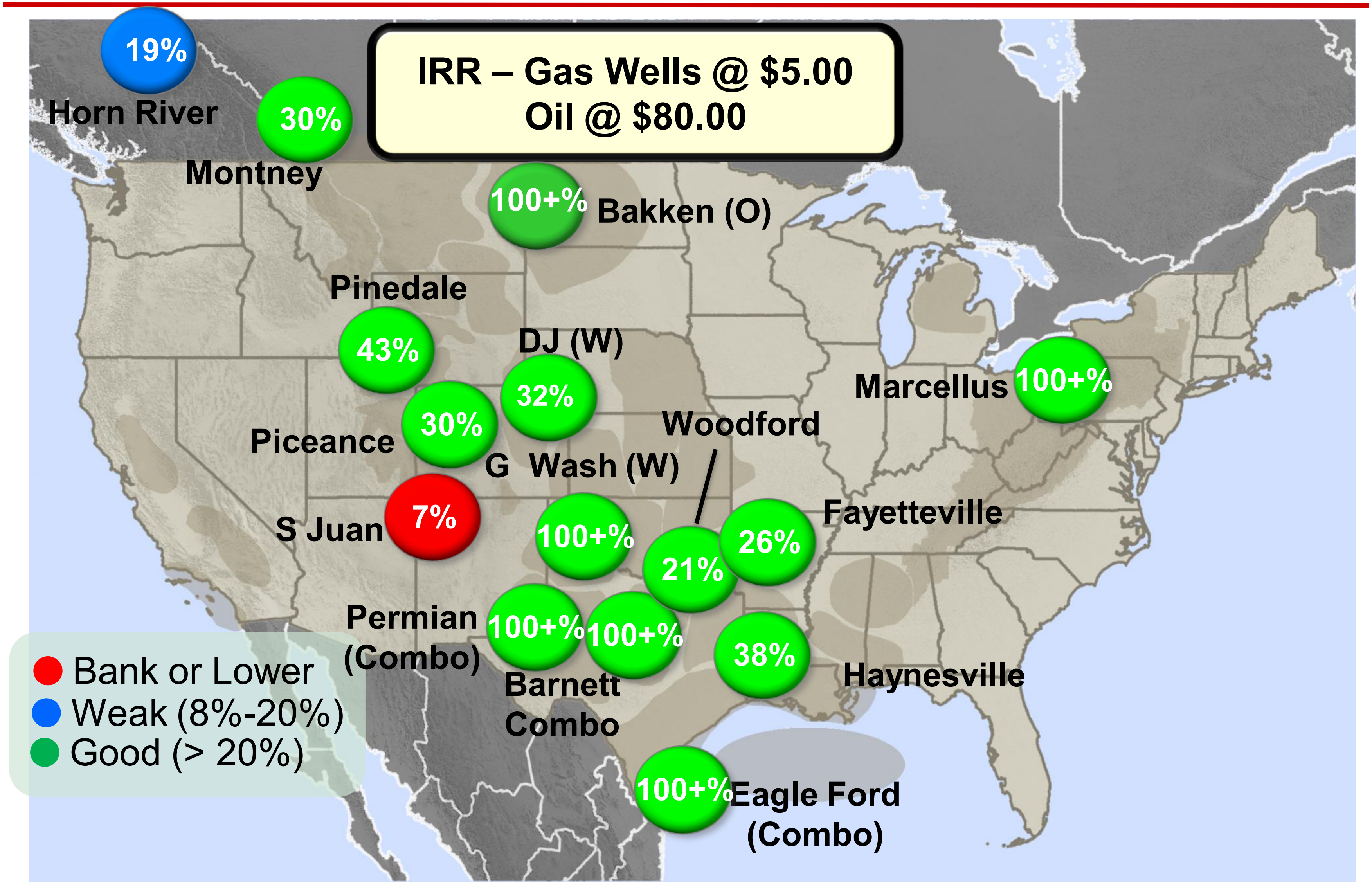
This slide **adds the value for oil in the Permian, Granite Wash (Anadarko) and Eagle Ford and liquids to the Marcellus and Barnett.** Simply adding those other commodities to the revenue stream bumps their returns to the stratosphere.

If you assume a higher gas price and/or a higher crude price the revenues go substantially higher for all of the areas.

The next slide illustrates the $5.00 gas option: virtually all basins have a strong IRR, but the impact on $110 crude would be far greater.

The point in these three slides is that producers anticipate high returns under virtually all conceivable scenarios right now. **Low gas prices will only impact drilling activity in a handful or regions (CBM). Given that the forward curve today is above $5.00, most producers do not anticipate prices below $4.00 for anything other than very short periods.** For the foreseeable future oil and liquids prices will have a far bigger impact on the market.

Comparative Rates Of Return



Conclusions & Implications

- Technology is radically transforming the natural gas and oil businesses resulting in vastly more relatively low-cost supplies. These technology changes will continue to evolve on the exploration, operations and environmental mitigation fronts.
- As a consequence, the US faces a period of time – through this decade – where prices will remain relatively low and flat, BENTEK believes between $4.00 to $5.00 per MMBtu. There will be periods where prices will temporarily fall below $4.00. This raises the prospect that natural gas industry will look increasingly like a technology-driven industry i.e. one typified by declining costs.
- Implications fall into several buckets
  - For producers and investors:
    - Economics will favor liquids and oil exploration over natural gas.
    - The producer community may split into “haves” and “have nots”, with lots of consolidation.
    - Midstream, transportation, processing and storage assets will continue to increase in value.
  - For consumers natural gas will provide an increasingly important alternative:
    - Natural gas will continue to gain market share relative to coal, alternative energy and possibly nuclear alternatives for power demand.
    - Natural gas vehicles will gain market share over electric alternatives.
    - Industry – both feedstock and thermal users – will increasingly rely on natural gas adding 1000s of jobs to the economy.
  - For state and federal policy makers, changes must occur to achieve maximum benefits:
    - Permitting must become far more expeditious and efficient.
    - In an era of tight budgets, resources should be placed where they can do the most good to facilitate the market, not used to subsidize politically motivated winners and losers; let the market evolve.
    - Policy decisions at either the state or federal levels increasingly will have competitive economic implications which can damage regional, state and local tax bases and economies.

TECHNOLOGY IS AND WILL CONTINUE TO TRANSFORM THE OIL AND GAS INDUSTRY AND MOST IMPORTANTLY CONTINUE TO DRIVE DOWN COSTS.

EXPECT GAS PRICES TO REMAIN IN THE $4-$5 RANGE FOR THE NEXT SEVERAL YEARS AND MOVE UP ONLY SLIGHTLY THROUGH THE DECADE. WE MAY SEE SHORT TERM SPIKES UP AND DOWN, BUT THEY WILL BE SHORT TERM ONLY. THE AVERAGE PRICE WILL BE VERY FLAT.

CONSEQUENCES WILL BE PROFOUND, CHANGING THE INDUSTRY, CONSUMERS, THE ENVIRONMENT AND THE ECONOMY.

GAS WILL BECOME THE DOMINANT POWER GENERATION FUEL, GRAB A LARGE SHARE OF THE TRANSPORTATION MARKET AND LEAD A RESURGENCE OF OUR NATION’S MANUFACTURING BASE.

IN TEN YEARS I EXPECT THAT WE WILL LOOK BACK AND SEE A NATION THAT HAS BEEN POSITIVELY RESHAPED ECONOMICALLY AND ENVIRONMENTALLY BY THIS TECNOLOGICAL TRANSFORMATION.

THANK YOU FOR YOUR TIME.

Questions?

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