An Energy Revolution: 35 Years of Fracking in the Barnett Shale

How North Texas Fracking Turned America Into an Energy Superpower

A North Texans for Natural Gas Special Report
June 1, 2016

Executive Summary

The United States is in the midst of an energy revolution. Once considered to have dwindling energy resources and a dangerous reliance on foreign imports, the United States now has the distinction of being the largest combined oil and natural gas producing country in the world. Few experts saw this transformation coming, and it was made possible by the use of hydraulic fracturing (fracking) and horizontal drilling, which allowed oil and natural gas to be unlocked from tight rock (shale) formations. This revolution first began in North Texas 35 years ago, with the Barnett Shale being the birthplace of modern-day fracking.

This report examines the history of the Barnett Shale, the role it has played in changing global energy dynamics, and the economic benefits it continues to provide to the Dallas-Fort Worth region.

Key Highlights

- ★ The fracking boom, which has transformed the global economy, began in North Texas.
- ★ Since 2003, the Barnett Shale has produced more than 15 trillion cubic feet of natural gas, enough to heat 225 million homes for one year.
- ★ The USGS recently doubled its assessment of the Barnett Shale, estimating it contains 53 trillion cubic feet of recoverable natural gas.
- ★ Just 28 percent of the Barnett Shale's natural gas resources have been developed; meaning production in the Barnett Shale hasn't even reached the half way point.
- ★ The Barnett Shale has provided $11.8 billion in gross product per year and created more than 107,650 permanent jobs in North Texas.
- ★ Lower natural gas prices from fracking resulted in annual savings of $432 per person in energy and home heating costs in Texas between 2007 and 2013.
- ★ Thanks to fracking, the United States is now the world's top oil and natural gas producer.
- ★ Today, nearly two-thirds of U.S. natural gas production comes from fracking, up from just one percent in 2000.
- ★ If Texas were a country, it would be the world's second largest natural gas producer. Among OPEC nations, only Saudi Arabia produces more oil than Texas.
- ★ Fracking helped the United States in 2015 post an annual trade surplus with OPEC for the first time ever.
- ★ The first shipment of U.S. crude oil overseas in more than 40 years was from the Eagle Ford Shale formation in south Texas.

George Mitchell was the first to hydraulically fracture a well in the Barnett Shale in the 1980s. His company, Mitchell Energy, spent the next two decades experimenting with new techniques and procedures. In 1997 the company began to use slick water fracks, which used primarily water and sand to fracture the rocks. This was a pivotal moment and proved for the first time that oil and natural gas resources could be efficiently developed from shale formations, which many in the industry believed to be cost prohibitive.

Energy companies soon discovered that immense volumes of oil and natural gas could be produced from shale formations throughout the country. The Marcellus Shale in Pennsylvania and the Bakkan Shale in North Dakota ultimately became some of the largest producing formations in the United States. Meanwhile, development in the Eagle Ford and Permian Basin in Texas solidified the state's position as the number one oil and natural gas producer in the country, and one of the leading producers in the world. Texas produces more oil than all OPEC countries except for Saudi Arabia – making it the sixth largest oil producer in the world.[1] In addition, Texas is second only to Russia in terms of natural gas production.[2]

Today, the Barnett Shale produces five billion cubic feet of natural gas per day. It provides low-cost energy for families and businesses all across North Texas, has helped create over 100,000 jobs in the region, and generates hundreds of millions of dollars in revenue for schools and local government.

Beyond the local economic benefits, the increased production of American energy has also helped to strengthen U.S. national security. In 2015, approximately 24 percent of the petroleum used in the United States came from foreign sources – the lowest percentage since 1970.[3] Through exports of oil and natural gas, the United States is now able to supply safe, secure, and reliable energy to allies across the world, while limiting the influence of hostile foreign nations.

None of this would have been possible, however, had it not been for the work and discoveries first made in the Barnett Shale.

Introduction

In President George W. Bush's 2007 State of the Union address, he told the American people:

> *"Extending hope and opportunity depends on a stable supply of energy that keeps America's economy running and America's environment clean. For too long, our nation has been dependent on foreign oil. And this dependence leaves us more vulnerable to hostile regimes and to terrorists who could cause huge disruptions of oil shipments and raise the price of oil and do great harm to our economy."* [4]

The President's remarks reflected the unrest felt throughout the country regarding declining U.S. energy resources and an increased dependence on foreign oil imports, which just a few years prior accounted for 60 percent [5] of energy consumed in the United States. However, few people realized at the time that the United States was on the cusp of an energy renaissance that would soon propel our country into a global energy leadership position.

This would all be made possible through the development and refinement of existing technologies, such as hydraulic fracturing (fracking) and horizontal drilling, which enabled the production of unconventional oil and natural gas resources – largely from shale. Fracking, a process in which fluids (comprised of 99 percent water and sand) are injected into a well at high pressure, causing rock formations at depth to fracture and release oil or natural gas, was already changing the way in which energy was produced. It was quietly unlocking vast amounts of oil and natural gas reserves that were previously considered impossible to develop.

The origin of fracking – enhancing flow rates by well stimulation – actually dates back to the 1860s when Edward A.L. Roberts used torpedoes in wells in Pennsylvania to stimulate oil production.[6] The first application of hydraulic fracturing was used in 1947 on a well (which is still producing today) in Grant County, Kansas. A few years later, Halliburton performed the first commercial frack job in Oklahoma.[7] However, the birthplace of modern-day fracking is right here in Texas.

In 1981, a businessman named George Mitchell set out to develop the Barnett Shale, located in the Fort Worth Basin in North-Central Texas. Geologists and engineers had long known that shale deposits like the Barnett contained vast quantities of natural gas, but getting the natural gas to flow from the rocks was considered too difficult and too expensive. Where others saw a waste of time and money, Mitchell saw potential, and for nearly two decades he experimented with different fluids and drilling techniques to try to "crack the code" of the Barnett.

Ultimately, the technologies first deployed in the Barnett Shale, including the use of a slick water frack and combining fracking with horizontal drilling, helped make the development of shale resources not only possible, but also economical. The groundbreaking work done in the Barnett Shale paved the way for the development of shale plays across the country, making new sources of oil and natural gas available for the first time ever.

What is Shale?

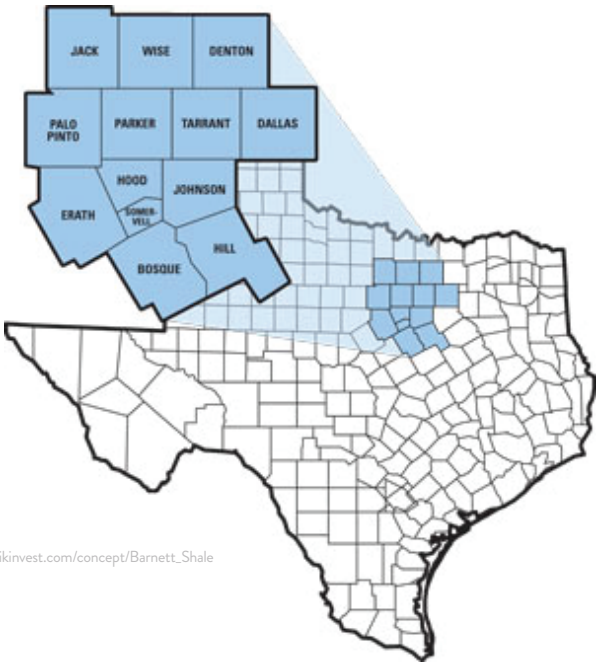
Shale is known as the "source rock" for oil and natural gas. It is a fine-grained sedimentary rock that is formed by the compaction of particles of clay and silt, or what is commonly referred to as mud.[8] These shale formations were formed some 300-400 million years ago during the Devonian period, when large portions of the United States were covered by water. As small aquatic organisms died and settled along the sea bed, they formed a layer of organic material. Eventually this organic material was buried and warmed by the earth, transforming it into hydrocarbons (oil and natural gas).[9]

Some of this oil and natural gas would migrate out of the shale, forming conventional reservoirs trapped within more porous rock layers such as sandstone. These were the first oil and natural gas resources discovered, and were developed using standard vertical extraction wells. These deposits, which are still being developed worldwide, are sometimes called "conventional oil and natural gas resources."[10]

However, most of the oil and natural gas would remain trapped within the tiny pores of the shale. Up until the late 20th century, it was believed that the oil and natural gas resources in these deep shale formations were unrecoverable. While they were recognized as being a prerequisite for finding good oil and natural gas reservoirs, they were largely unstudied as potential reserves themselves.[11] This all changed with the application of modern-day fracking, which finally allowed these unconventional oil and natural gas resources to be

Unlocking the Barnett Shale

The Barnett Shale in Texas was the first major unconventional shale formation to be successfully developed in the United States. Located in North-Central Texas, the Barnett Shale spans over 5,000 square miles and encompasses 25 counties in Texas. The formation is named after John W. Barnett, who settled in San Saba County in the late 19th century and named a local stream the Barnett Stream. In the early 20th century, geologists noticed black organic shale close to the stream and named it the Barnett Shale.[12]



http://www.wikinvest.com/concept/Barnett_Shale

TEXAS COUNTIES WITH PRODUCING WELLS IN THE BARNETT SHALE[13]

- DENTON
- JOHNSON
- TARRANT
- WISE
- ARCHER
- BOSQUE
- CLAY
- COMANCHE
- COOKE
- CORYELL
- DALLAS
- EASTLAND
- ELLIS
- ERATH
- HAMILTON
- HILL
- HOOD
- JACK
- MONTAGUE
- PALO PINTO
- PARKER
- SHAKLEFORD
- SOMERVELL
- STEPHENS
- YOUNG

George Mitchell, a Houston oil man and founder of Mitchell Energy, was the first to successfully develop the Barnett Shale and is known as the "Father of Fracking."[14] Though he may not have invented the practice, his contributions were nonetheless revolutionary.

Mitchell's interest in the Barnett Shale began in the 1950s. While reviewing well logs, Mitchell saw what looked like a layer of impermeable rock underneath wells drilled just north of Fort Worth and believed the rock potentially contained large volumes of trapped natural gas. Soon after, Mitchell bought the rights to drill on 3,000 acres in Wise County, Texas.[15]

Mitchell drilled his first well on that land, the D.J. Hughes #1, in 1951. It struck natural gas and his company soon began drilling other natural gas wells in the area while simultaneously acquiring new leases. At this time, he was drilling into shallow sandstone that had natural fractures. He began using a new technique known as hydraulic fracturing, which was first used commercially only a few years earlier, in order to create new cracks in the sandstone that enabled the natural gas to escape. The natural gas he was recovering was essentially the gas that had escaped and migrated up from the Barnett Shale. Tremendous amounts remained trapped deep underneath, but there was no known way of getting the natural gas out of the deep shale rock.[16]

The Barnett Shale remained mostly an enigma for decades. It was not included in early studies that assessed the resource potential of unconventional natural gas in the United States, and, even in 1992 the National Petroleum Council didn't include the Barnett Shale in its assessment due to "limited knowledge" of the formation.[17] Nevertheless, George Mitchell remained determined to figure out how to crack open this massive energy resource, and in 1981 he directed his team of engineers to find a way to develop the Barnett source rock. [18]

Two external factors contributed to George Mitchell's eventual unlocking of the Barnett Shale. First, Mitchell Energy had a contract with the Natural Gas Pipeline Company of America to feed its pipeline that delivered natural gas to Chicago. Mitchell Energy's natural gas reserves were depleting at the time, and the company needed to find new sources for the pipeline in order to meet its contractual obligations.[19] This contract also created financial advantages for Mitchell Energy, because it guaranteed prices that were considerably higher than market prices. This gave Mitchell the necessary resources to invest in new technologies. Dan Steward, VP of Mitchell Energy noted:

> *"Mitchell was selling his gas [for a] dollar and a quarter over the spot price. We would never have been able to do what we did in the Barnett without that. Mitchell had the money to invest in R&D. And he had a vision."* [20]

Second, in 1978 the federal government took steps to encourage new exploration of natural gas in order to address an impeding shortage. It began funding Research and Development (R&D) programs and provided tax credits and incentive pricing for producing unconventional natural gas.[21] Natural gas that came from unconventional reservoirs received higher prices. Mitchell Energy applied for the designation of a new field called Newark East in the Barnett Shale that qualified for this higher pricing.[22]

In 1981 Mitchell Energy drilled the first well in the Barnett Shale, the C.W. Slay #1 located in Wise County. Fracking was used to stimulate the Barnett Shale and it began actively producing natural gas in 1982 - albeit small amounts compared to today's standards.[23] That first year, the well produced 120 thousand cubic feet of natural gas per day. In 1983 the well was refractured using carbon dioxide foam and production increased to 274 thousand cubic feet of natural gas per day.[24] Upon further studies, Mitchell realized there were potentially billions or even trillions of cubic feet of natural gas located in Barnett Shale. In an interview, Mitchell noted:

> *"It was a substantial amount of gas if we could break it away from the rock."* [25]

Throughout the next decade, Mitchell Energy completed 100 wells[26] in the Newark East field, testing out different types and methods of fracking to see what would work best. It was Mitchell's personal persistence, in the face of opposition and critics (even from within his own company), that led to the development of newer and better fracking techniques. In an in interview with Forbes in 2009, Mitchell recalled:

> *"My engineers kept telling me, 'You are wasting your money, Mitchell.' And I said, 'Well damn it, let's figure this thing out, because there is no question there is a tremendous source bed that's about 250 feet thick."* [27]

The ability of Mitchell Energy to deepen its existing wells down to the Barnett Shale source rock also helped from a financial standpoint. The company saved money by not having to drill brand new exploratory wells that may or may not have resulted in large enough quantities of natural gas to be economic. From 1987 to 1997, Mitchell Energy completed 304 wells that were considered to be commercial. According to Steward, the return on these wells was "sufficient for proceeding with a Barnett development program." [28]

In 1991, with assistance from the Gas Research Institute (GRI) – a publicly funded non-profit established by the natural gas industry to conduct R&D – Mitchell Energy drilled its first horizontal well in the Barnett Shale.[29] An assessment of this well, conducted by GRI in 1993, concluded that "the Barnett Shale drilling and completion economics favor hydraulic fracturing in vertical wells." [30] While two additional horizontal wells were drilled in 1998, Mitchell Energy largely went back to drilling vertical wells. [31]

A major breakthrough came in 1997 when the first **slick water frack** was used.[32] Up until this time, fracking had been done by using foamed carbon dioxide and water (foam fracking) and later by using a gel formula. The gel would be injected into the well at high pressure to crack the rock and then it would be retrieved, leaving sand behind as a proppant to keep the cracks open. The problem with this method is that sometimes not all of the gel could be retrieved. When the gel hardened, it caused clogs in the cracks, making it more difficult for the natural gas to escape.[33] This led Mitchell Energy engineer Nick Steinsberger to come up with the idea of using water instead of gel to frack the Barnett Shale. While water had been used for fracking in the past, it had only been done in permeable sandstones that were easier to crack. Many thought it would be impossible to crack dense, impermeable shale rock.

What is a Slick Water Frack?

A slick water frack uses high volumes of water to fracture a well. The fluid is comprised of 99 percent water and sand, with the remaining fluid consisting of common additives that are found in the home. Other types of fracking techniques used foamed carbon dioxide or gels to fracture a well.

The slick water frack was first used and developed by Union Pacific Resources (UPR) in East Texas. It used water mixed with sand as the proppant and small amounts of polymers for lubrication. While UPR was not [34] fracking into shale, they were still having successful results using this method in hard, impermeable rocks. Steinsberger learned of this method from UPR and, with their permission, applied the technique in the Barnett Shale. Other engineers at Mitchell Energy thought it was a "stupid idea" and "not going to work." One noted that it was "counter to everything you were taught in school."[35] Still, Steinsberger continued to test different types of water mixtures hoping to see results. After multiple failed attempts, Steinsberger finally successfully used a slick water frack on his fifth well, the S.H. Griffin #4, located near Ponder, Texas.

The S.H. Griffin #4 produced 1.3 million cubic feet of natural gas per day for the first 90 days, an unbelievable amount for the time.[36] Steinsberger, in an interview with The Atlantic, said,

> *"This was the 'aha moment' for us, it was our best well ever in the Barnett, and it was a slick water frack. And it was my baby!"* [37]

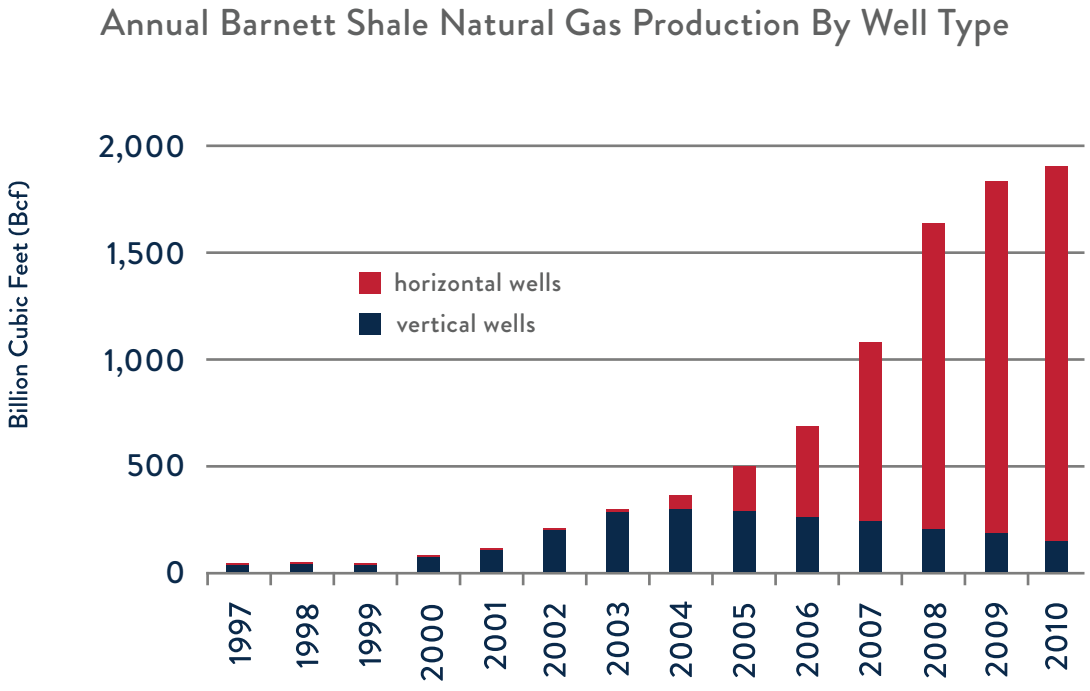
This was a revolutionary moment, marking the beginning of modern-day fracking in shale as we know it. Since the S.H. Griffin, more than a hundred thousand wells have been fracked in the United States, and most of them use a technique similar to what was first done in the Barnett Shale.[38] Steinsberger had finally figured out how to get shale rock formations to give up their natural gas and do so in an economical way.

In addition to increasing production rates, the method also reduced costs by 50 percent or more.[39] According to then Vice President of Mitchell Energy Dan Steward, it had cost $375,000 per well using gel fracking, and just $85,000 for a slick water frack.[40]

This method of fracking was soon applied to other wells in the Barnett Shale, and "by 2000 production had taken off like a rocket," according to Steward.[41] Production reached 365 million cubic feet per day in 2001, representing a 250 percent increase in just two years.[42] Around this time Mitchell Energy also became the first to successfully use microseismic fracture mapping of the Barnett Shale to improve the placement of the frack and its direction.[43]

In 2002, Devon Energy, recognizing the tremendous potential that existed in the Barnett Shale, acquired Mitchell Energy. The engineers at Devon introduced the idea of combining horizontal drilling with the slick water frack and seismic mapping done by Mitchell Energy.[44] Wells up until this point had been drilled down vertically and were several thousand feet deep. Horizontal wells were first drilled vertically into the shale formation, then turned and extended through the rock horizontally.[45] Combining this type of horizontal well with modern day hydraulic fracturing techniques enabled Devon to access larger volumes of natural gas from a single well. Devon Energy drilled its first horizontal well in the Barnett in June and July of 2002.[46]

The widespread application of these two techniques (horizontal drilling and hydraulic fracturing) quickly accelerated production in the Barnett Shale. According to the U.S. Energy Information Administration (EIA), by 2004 there were roughly 400 producing horizontal wells. By 2010 there were more than 10,000 horizontal wells, which accounted for the majority of production in the Barnett Shale.[47]



Source: U.S. Energy Information Administration

It wasn't long before the Barnett Shale caught the interest of other exploration and production companies looking to capitalize on this newly discovered resource. Companies such as Chesapeake Energy, XTO Energy and EOG Resources, among others, all acquired leases in the Barnett Shale, and by 2005 the region was producing half a trillion cubic feet of natural gas per year.[48]

Eventually, companies expanded their focus to other shale formations across the country, hoping to replicate the success of the Barnett Shale. The Fayetteville Shale in Arkansas was the second shale play to be developed, followed by the Haynesville Shale in Louisiana/East Texas and the Marcellus Shale and Utica Shale in Pennsylvania and Ohio. Development in these shale formations grew rapidly between 2006 and 2011.[49]

Companies also discovered that those same hydraulic fracturing techniques could be used to coax oil out of tight formations. Soon the Bakken and Three Forks formations in North Dakota and Montana were being developed. The Eagle Ford Shale in South Texas quickly became one of the most prolific oil fields in the world. The Permian Basin in Texas, a major oil field but one that many believed to be in decline, was rejuvenated as producers found a "tiramisu"[50] of highly productive shale formations.[51] While these are largely tight oil plays, several also produce natural gas and natural gas liquids.

A rapid increase in U.S. energy production followed, which in turn dramatically altered U.S. energy policy. Suddenly, the United States went from having limited oil and natural gas resources to becoming the world's leading producer. This was all made possible by George Mitchell's breakthrough work in the Barnett Shale.

Timeline of Barnett Shale Development

1951: George Mitchell drills his first well in Wise County, TX

1981: C.W. Slay #1 is the first well drilled and fracked in the Barnett Shale

1981 - 1997: Mitchell Energy experiments with different types of fracking techniques, conducts seismic mapping of the Barnett Shale

1997: The first application of a slick water frack, proving that shale formations can be economically developed

2002: Devon Energy acquires Mitchell Energy, combines horizontal drilling with the slick water frack

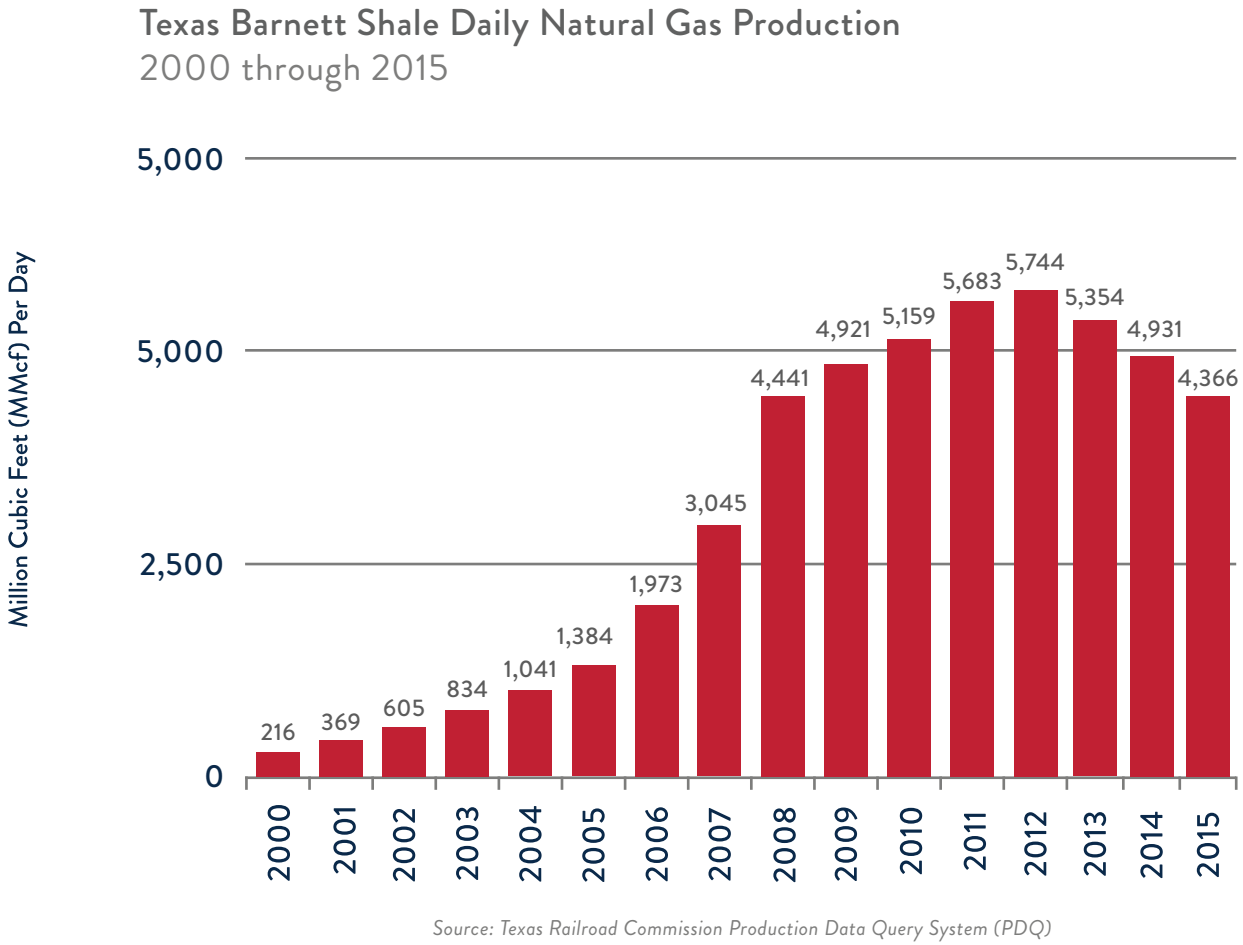
2005: Wells in the Barnett Shale produce more than half a trillion cubic feet of natural gas per year

2007: 63% of all U.S. shale gas production comes from Texas, largely from the Barnett Shale

2015: USGS doubles its assessment of resources in the Barnett Shale, estimating it contains 53 trillion cubic feet of natural gas and 172 million barrels of oil

Resources in the Barnett Shale

Once ignored by petroleum geologists and energy companies, the Barnett Shale suddenly became an epicenter for American energy development in the 21st century. The combined use of hydraulic fracturing and horizontal drilling in 2003 turned the Barnett Shale into a major natural gas field. Since that time, more than 16,000 horizontal wells have been drilled in the Barnett, producing more than 15 trillion cubic feet (Tcf) of natural gas and 59 million barrels of oil.[52] To put this amount into perspective, one Tcf of natural gas is enough to heat 15 million homes for one year, generate 100 billion kilowatt-hours of electricity, or fuel 12 million natural-gas-fired vehicles for one year. [53]



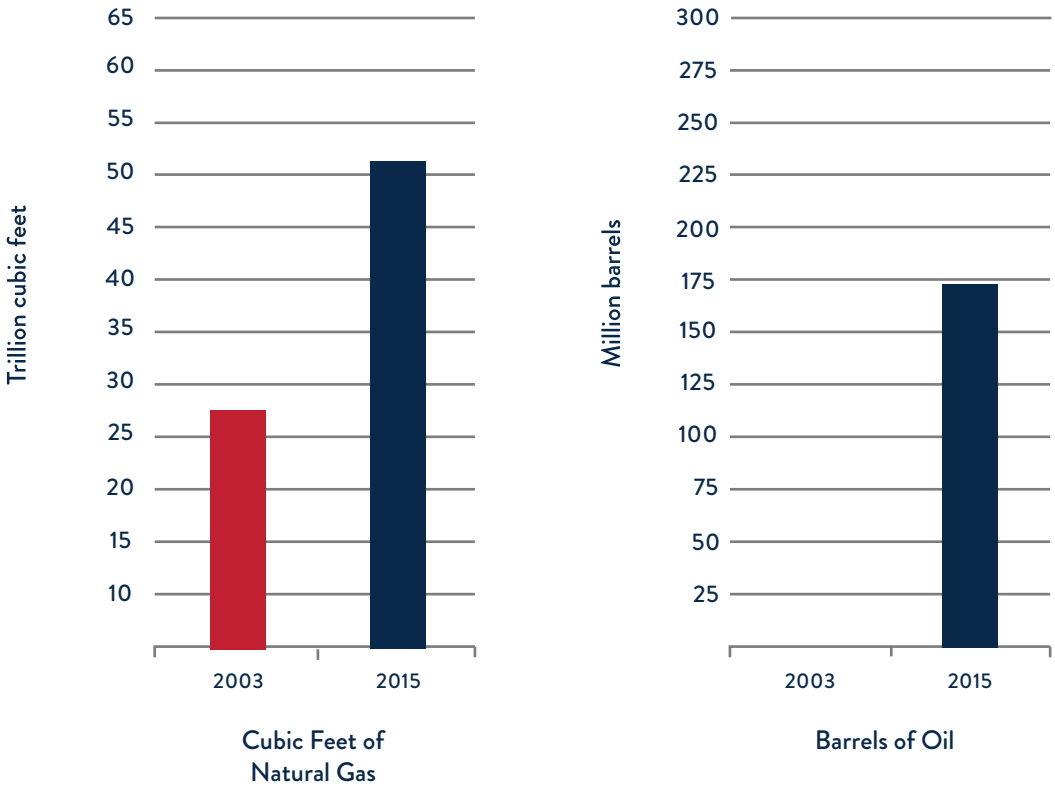
Source: Texas Railroad Commission Production Data Query System (PDQ)

For a decade, the Barnett Shale was the largest natural gas-producing field in the United States. In 2007, 63 percent of all U.S. shale gas production was from Texas,[54] largely due to production in the Barnett Shale. It wasn't until 2011 that the Haynesville formation in Louisiana surpassed the Barnett as the leading producer. The EIA noted that "experience gained from early horizontal drilling programs at the Barnett has helped the Haynesville operators ramp up natural gas production far more rapidly." [55] The Marcellus Shale now holds the distinction of being the largest shale gas play in the United States, producing over 17.4 billion cubic feet of natural gas every day.[56]

Despite reaching peak production in 2012, the Barnett Shale continues to be a significant producer of natural gas and will continue to do so well into the future. In December 2015, the U.S. Geological Survey (USGS) released an updated assessment of the Barnett Shale's undiscovered, technically recoverable resources and found that it has considerably more natural gas than previously thought. According to the USGS, the Barnett Shale is estimated to contain 53 trillion cubic feet of recoverable natural gas – double the amount that the USGS estimated in 2003. Furthermore, they found that the Barnett Shale contains 172 million barrels of recoverable shale oil and 176 million barrels of recoverable natural gas liquids.[57] The USGS called the Barnett Shale a "significant source of potential natural gas resources" and noted that the "substantial increase in potential resources is largely due to the oil and gas industry's switch to primarily horizontal drilling within the Barnett, paired with hydraulic fracturing." [58]

With over 15 trillion cubic feet of natural gas produced from the Barnett Shale to date, this new estimate means that just 28 percent of the formation's natural gas resources have been developed. Producers haven't even reached the half way point yet when it comes to developing the Barnett Shale.

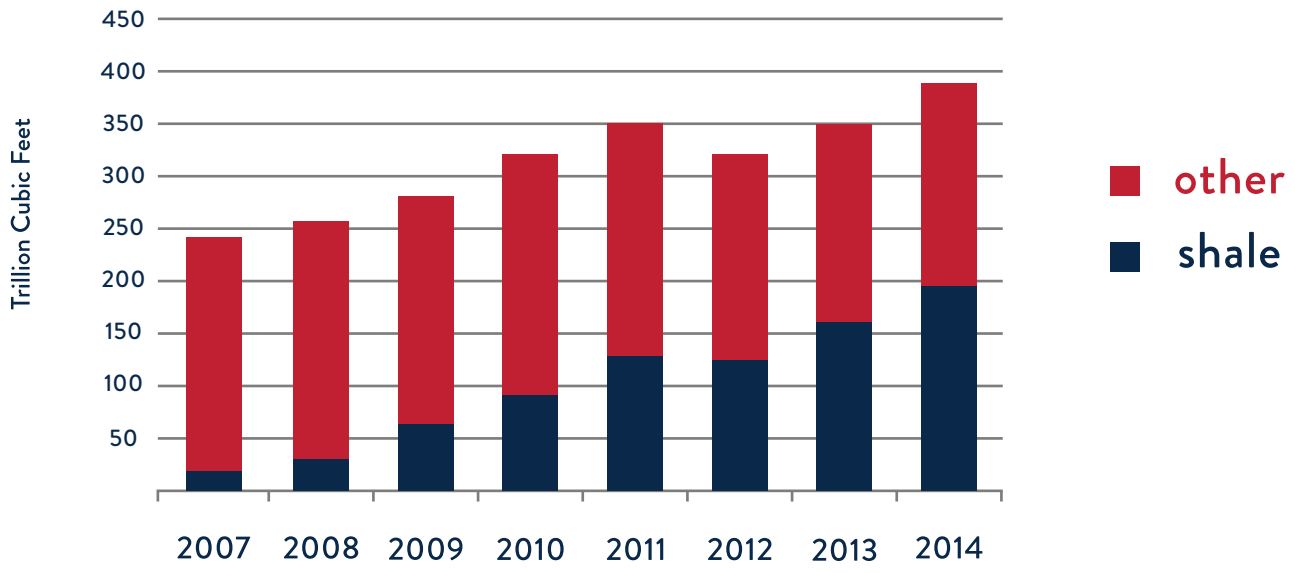
USGS Estimates of Oil and Natural Gas Resources in the Barnett Shale



The Growing Role of Shale Gas and Tight Oil

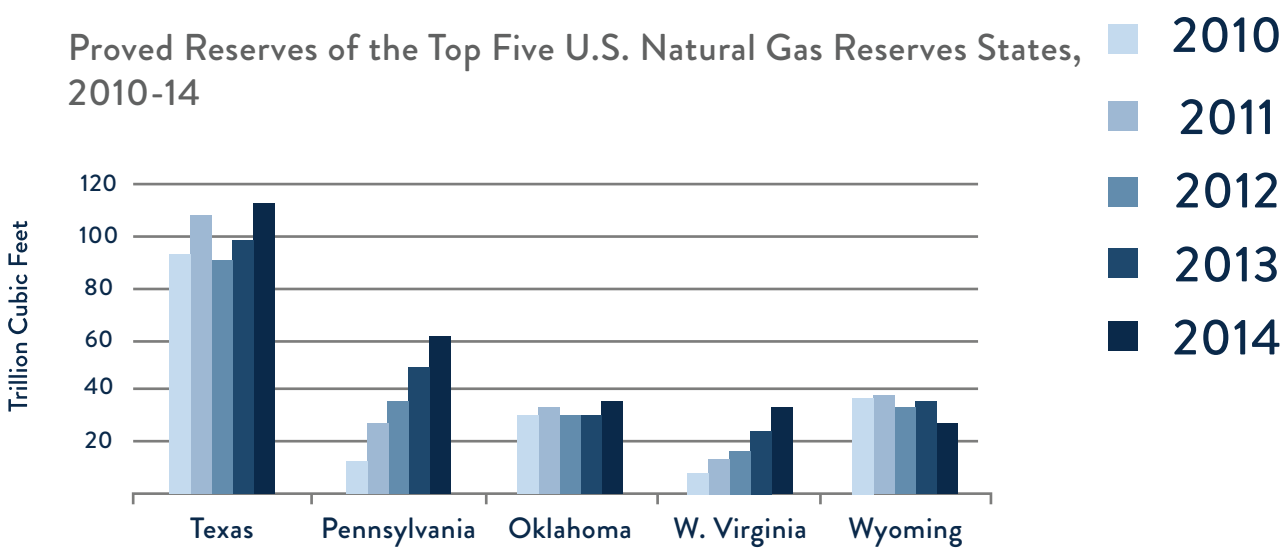
Until Mitchell Energy discovered the secret to unlocking shale formations, no one realized the tremendous amount of oil and natural gas resources that existed in the United States. In 2000, the EIA estimated that proved reserves of natural gas (those that are recoverable under current economic and production conditions) amounted to 186.5 trillion cubic feet. By 2014, EIA's estimate for proved natural gas reserves would more than double to a record-high 388 trillion cubic feet, with shale gas accounting for over half of this amount.[59]

U.S. Total Natural Gas Proved Reserves (shale and other resources)



Source: U.S. Energy Information Administration, Form EIA-23L, Annual Survey of Domestic Oil and Gas Reserves, 2007-14

Texas, largely due to its shale gas plays, continues to have the largest proved natural gas reserves in the United Sates. [60]



Note: Total natural gas includes natural gas plant liquids that have yet to be extracted downstream, and does not include lease condensate
Source: U.S. Energy Information Administration, Form EIA-23L, Annual Survey of Domestic Oil and Gas Reserves, 2010-14

Similarly, proved reserves of U.S. oil have grown from 23.5 billion barrels in 2000 to 40 billion barrels in 2014, a 70 percent increase. Tight oil plays from shale formations currently account for 33 percent of proved oil reserves. The Eagle Ford and Permian Basin in Texas are two of the top three producing tight oil plays in the United States.[61]

It's important to keep in mind that proved reserves are a very conservative estimate of oil and natural gas resources, and they are based on current economic and production conditions. Estimates for technically recoverable resources (those than can be produced based on current technology) are much larger and show the true scope and volume of shale resources in the United States. According to the EIA, the United States has approximately 610 trillion cubic feet of technically recoverable shale natural gas resources and 59 billion barrels of technically recoverable tight oil resources.[62]

The emergence of shale gas and tight oil has changed the way the Americans both produce and consume energy. In 2000, just one percent of the U.S. natural gas supply came from shale gas.[63] Today, two-thirds of U.S. natural gas production comes from fracking,[64] and half of all American oil production is made possible by fracking.[65] As a result of this newly unlocked supply, by the end of 2016, EIA estimates that natural gas will surpass coal as the number one source of power generation in the United States.[66]

Economic Benefits of the Barnett Shale

Increased production of natural gas has provided significant benefits to Texas and the country as a whole. Economic growth and job creation, higher government revenues, lower electricity prices, and enhanced national security are just a few of the benefits made possible by development of the Barnett Shale and subsequently the many other shale formations across the country.

A 2015 study by the Brookings Institute found that the shale gas boom has helped lower natural gas prices by 47 percent, resulting in total consumer savings of $74 billion. In Texas alone, lower natural gas prices led to an annual savings of $432 per person from lower energy and heating costs between 2007 and 2013.[67]

The Barnett Shale has also been a key driver of North Texas' economy. A recent study by The Perryman Group found that the Barnett provided $11.8 billion in gross product per year and supported more than 107,650 permanent jobs in the region.[68]

Economic Benefits of Shale Production in North Texas

- The Barnett Shale has created over 107,650 jobs in North Texas
- The Barnett Shale provides $11.8 billion in gross product per year
- Lower natural gas prices resulted in $432 in annual savings per person from 2007-2013
- Properties in the Barnett Shale saw a 5 to 6 percent increase in property value from 1997 to 2013
- Northwest Independent School District received over $20 million in property tax revenue from oil and natural gas producing properties in FY 2014

Jobs created by Texas shale development not only include exploration and production work but also jobs along the entire supply chain, from manufacturing and maintenance to construction, pipelines, and technology. For example, according to the American Chemistry Council, the increase in U.S. shale gas production – and the resulting low price of natural gas – is leading to new investments and growth for U.S. petrochemical manufacturers. As of September 2014, $45.8 billion of potential investment in new chemical manufacturing facilities or expansion projects were headed for Texas. These new investments could generate 153,000 permanent new jobs throughout the supply chain by 2023, and $7.5 billion in wages for Texas workers.[69]

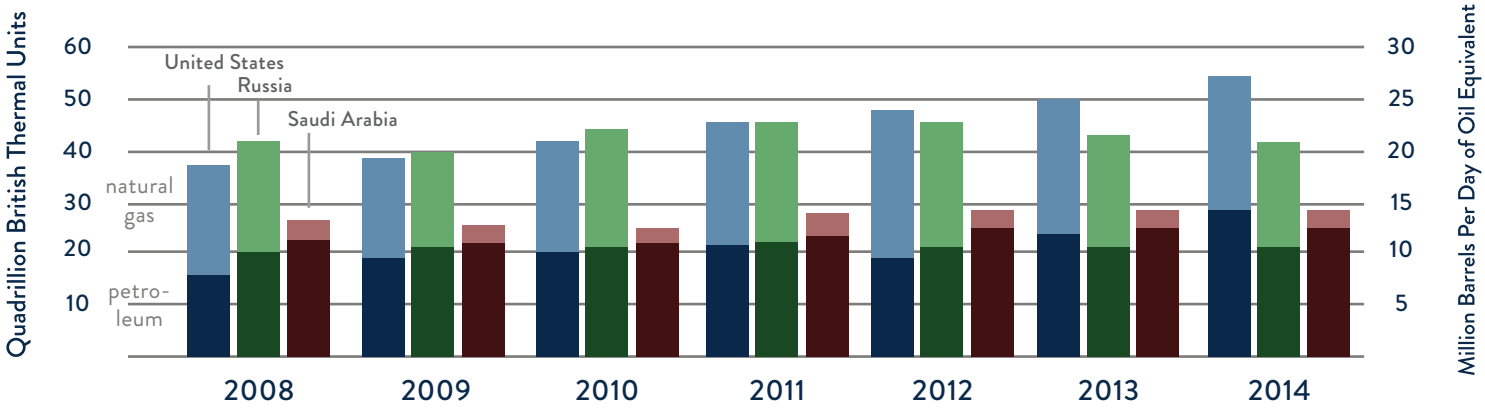
Through taxes and royalty payments, energy production in the Barnett Shale has also provided a considerable source of revenue to cities, counties, and schools. According to The Perryman Group, the Barnett Shale has helped generate $644 million in annual tax receipts to local government entities.[70] In addition, students in the region have directly benefited from education funding provided by energy production. As described in a recent report by North Texans for Natural Gas, the oil and natural industry contributes over $4 billion per year to the Texas education system.[71]

Oil and natural gas production has also had a positive impact on property values. According to a 2014 study, properties in the Barnett Shale appreciated faster than those in non-shale producing areas and saw five to six percent increase in values from 1997 to 2013.[72] Increased property values expand the local tax base, which also leads to higher revenues for local schools. Independent School Districts located in the Barnett Shale also benefit from oil and natural gas property taxes. For example, Northwest ISD, located in Denton, Tarrant, and Wise Counties, received just over $20 million in property tax revenue from oil and natural gas producing properties in fiscal year 2014.[73]

The United States Becomes a World Energy Leader

Perhaps the biggest and most important benefit of the fracking revolution is that it has ushered in an era of American energy abundance. The dramatic increase in both oil and natural gas production has turned the United States into a global energy superpower. Thanks to fracking, the United States is now the world's leading producer of oil and natural gas, surpassing both Russia and Saudi Arabia.[74]

Estimated U.S., Russia, and Saudi Arabia Petroleum and Natural Gas Production



Source: U.S. Energy Information Administration
Note: Petroleum production includes crude oil, natural gas liquids, condensates, refinery processing gain, and other liquids, including biofuels. Barrels per day oil equivalent were calculated using a convention factor of 1 barrel oil equivalent = 5.55 million British thermal units (Btu)

The shale gas boom that started in Texas is not only benefiting the United States but indeed the entire world. As Daniel Yergin, Pulitzer-Prize winning author and Vice-Chairman of IHS, wrote in the *Wall Street Journal*,

> *"George Mitchell's breakthrough in the Barnett Shale has opened the door to a potentially profound change in the global energy equation."*[75]

Increased U.S. energy production has helped strengthen U.S. national security by decreasing our country's dependence on foreign nations for its energy. In 2013, the United States produced more oil than it imported for the first time since 1995.[76] According to the EIA, the United States is also on track to be a net exporter of natural gas by 2017. Since 2008, imports of natural gas into the United States have declined by 31 percent, while U.S. exports of natural gas have increased by 90 percent.[77] For the first time ever, the United States in 2015 recorded an annual trade surplus with OPEC, finishing the year with a $6.6 billion surplus.[78] Petroleum imports now account for less than 10 percent of the total U.S. trade deficit, down from 60 percent in 2011.[79]

In recognition of America's growing energy resources, the U.S. Congress passed and the President signed legislation in December 2015 to end the 40-year old ban on U.S. crude oil exports. On December 31, 2015, the first tanker carrying U.S. crude oil overseas set sail from Corpus Christi, Texas. The oil had been produced from the Eagle Ford Shale.[80] Since then, U.S. oil has been exported all over the world to countries such as Israel, Netherlands, France, Germany, Italy, Panama, and Japan.[81] Venezuela, which has the world's largest crude oil reserves, has even imported U.S. oil – with orders already totaling nearly 7 million barrels. This is a stark reversal of roles, considering the United States just last year was importing approximately 800,000 barrels per day from Venezuela.[82]

U.S. crude oil exports have been called a "game changer" by experts, causing a shift in global power. As explained by Mark Mills, a senior fellow at the Manhattan Institute, a public policy think tank:

> *"If you're a buyer in, say, South Korea, and you're offered the same price from Saudi Arabia, Russia and the U.S., you're going to make the obvious choice: the U.S. It's the one supplier you know is never going to threaten you or cut off supplies, which is certainly not the case with Saudi Arabia, Russia or Iran."* [83]

Much like what is happening with oil, exports of U.S. natural gas are also expected to change world energy markets. In another significant development, the first major shipment of U.S. liquefied natural gas was sent to Brazil at the end of February 2016.[84]

The rise of American energy production, and the United States' new ability to export its energy resources, will enhance national security by providing greater stability to world markets and a new tool for U.S. foreign policy leaders. Former CIA Director and Defense Secretary Leon Panetta and former National Security Advisor Stephen Hadley articulated this point in the *Wall Street Journal*:

> *"Too often foreign-policy debates in America focus on issues such as how much military power should be deployed to the Middle East, whether the U.S. should provide arms to the Ukrainians, or what tougher economic sanctions should be imposed on Iran. Ignored is a powerful, nonlethal tool: America's abundance of oil and natural gas.* ***The U.S. remains the great arsenal of democracy. It should also be the great arsenal of energy."*** [85]

Conclusion

Texas has long enjoyed the distinction of being the top oil and natural gas producing state in the country. However, it's not just its bountiful resources but the drive and ingenuity of its people that have made such a lasting impact on the world. By discovering how to free the natural gas and oil locked in shale formations, George Mitchell and his team did something that no one thought possible – and it forever changed the face of modern-day energy production.

In 2013, George Mitchell passed away at the age of 94. But people all over Texas are still benefitting from his legacy, as will countless future generations. Once called the "Steve Jobs of the oil industry,"[86] Mitchell's stubborn vision for his small energy company ultimately caused reverberations from Dallas to Dubai. As the Houston Chronicle noted in its obituary to Mr. Mitchell:

> *"Two decades before his innovations in hydraulic fracturing achieved economically feasible production of natural gas from the tight Barnett Shale of North Texas, he envisioned that the shale resources in North America could change the country's energy outlook. Flying in the face of a barrage of naysayers, his multi-decade, high-risk commitment to crack the shale, literally and intellectually, has now fundamentally altered world energy markets."*[87]

The Barnett Shale has the distinction of being the birthplace of Mitchell's energy revolution. Thanks to production in the Barnett Shale, billions of dollars have flowed into the Dallas-Fort Worth economy, over a hundred thousand jobs have been created in the region, and local schools are some of the best-funded in the state.

Without a doubt, the current depressed market conditions have impacted production in the Barnett Shale – along with other energy projects all across the country. The world supply of oil and natural gas is at an all-time high, in part due to increased production in the United States and high output by OPEC. This has caused prices to drop considerably, and although this has benefitted consumers in the form of lower gasoline prices and cheaper monthly energy bills, the current downturn also has public budget, employment, and other economic impacts. Despite these challenges, oil and natural gas production in the Barnett Shale and other formations in Texas will continue to provide a wealth of opportunities and benefits for the state.

While new activity and drilling in the Barnett Shale is down, production from existing wells remains high. Today, Barnett Shale wells are producing 5 billion cubic feet of natural gas per day, higher than what they were producing in 2008.[88] USGS' recent assessment showing reserves in the Barnett Shale are more than double original projections is further evidence that the Barnett Shale will continue to be an active and important shale play well into the future. Additionally, low production costs and access to pipelines will continue to make this a desirable location for producers. Drilling a well in the Barnett Shell is less expensive than other parts of the country – costing around $3 to $4 million per well compared to upwards of $10 million in some other formations.[89]

George Mitchell's work in the Barnett Shale will go down in history as one of the most significant developments in energy production, both in the United States and around the world. The breakthrough of combining hydraulic fracturing with horizontal drilling to access shale resources forever changed the rules of the game and finally put the United States on a path towards true energy security.

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