THE FUTURE OF SHALE

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THE FUTURE OF SHALE

A

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By

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Abstract

This project examines the various drivers that led to the U.S. shale oil revolution in order to predict its place in the energy industry going forward and to analyze its effects on Alaska. The shale boom flooded the market with oil causing a dramatic decrease in crude oil prices in late 2014. With this price drop threatening to send Alaska into an economic recession, the future of shale should be of primary concern to all Alaskans as well as other entities that rely heavily on oil revenue.

The primary driver leading to the shale revolution is technology. Advances in hydraulic fracturing, horizontal drilling, and 3D seismic mapping made producing shale oil and gas possible for the first time. New technologies like rotary steerable systems and measurements while drilling continue to make shale production more efficient, and technology will likely continue to improve. Infrastructure helps to explain why the shale revolution was mostly an American phenomenon. Many countries with shale formations have political infrastructure too unstable to risk shale investment. Capital infrastructure is a primary strength of the U.S. and also helps to explain why shale development didn't find its way up to Alaska despite having political stability. Financial infrastructure allowed oil companies to receive the funding necessary to quickly bring shale to the market. The final driver explored is crude oil prices. High oil prices helped spark the shale revolution, but with the recent price crash, there is uncertainty about its future. With production costs continually falling due to technology improvements and analysts predicting crude oil prices to stabilize above most project breakeven points, the future of shale looks bright.

The Future of Shale

Image compilation – see bibliography for sources

An analysis on the U.S. shale revolution and its effects on Alaska.

By: Michael Malin

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Introduction

The shale revolution caught most by surprise. In the 2012 U.S. presidential debates, the importance of energy independence was one of the few issues President Obama and Governor Romney had in common. Energy policy was not only viewed as economically vital, but also as an issue of national security. That being said, most experts believed policies to increase energy independence to be wishful thinking. After one of these debates, Reuters responded with an article titled "Energy Independence is a Farce" (Adler, 2012). While this sentiment seemed to be the consensus at the time, an energy revolution was already in the works. According to the *Wall Street Journal*, "…on the way to Barack Obama and Mitt Romney's goal of greater U.S. energy independence: American industry got there first" (Bussey, 2012).

The answer to the problem of energy independence was the shale energy revolution. Over the next four years oil production in the United States skyrocketed. From the Wall Street Journal, "Driven by new fields such as the Bakken in North Dakota, U.S. oil production has hit levels not seen since 1998" (Bussey, 2012) and according to the U.S. Department of Energy (DOE), the U.S. became a net exporter of petroleum products for the first time since 1949. Citigroup has gone as far as to call the US "The new Middle East." Few will deny the massive impacts of the shale revolution but with the crude oil price crash in late 2014, its future is uncertain.

Shale & Alaska North Slope (ANS) Crude Oil Prices

While the shale revolution is having many positive effects around the world, not everyone is a winner. With Alaska shale formations still untouched, Alaskans have not reaped many of the benefits that other energy-rich states enjoyed. With about 90% unrestricted funds historically coming from oil revenue, the drop in oil prices has had an adverse effect on revenue. Many experts believe that this price drop was also due to the recent shale developments.

British Petroleum (BP) has been predicting a price drop from as early as 2012. Their argument was simple: U.S. supply is increasing faster than world demand which should lead to lower prices. Even as prices continued to climb, BP did not back down from their stance. Their claim was that the increased supply was being offset by supply disruptions around the world. From the 2013 BP Statistical Review, "We are familiar with the ongoing story of rapid growth in the US; but it was also yet another year of significant supply disruptions, most notably in North Africa and the Middle East." Figure 1 demonstrates this uneasy equilibrium where supply remained relatively unchanged.

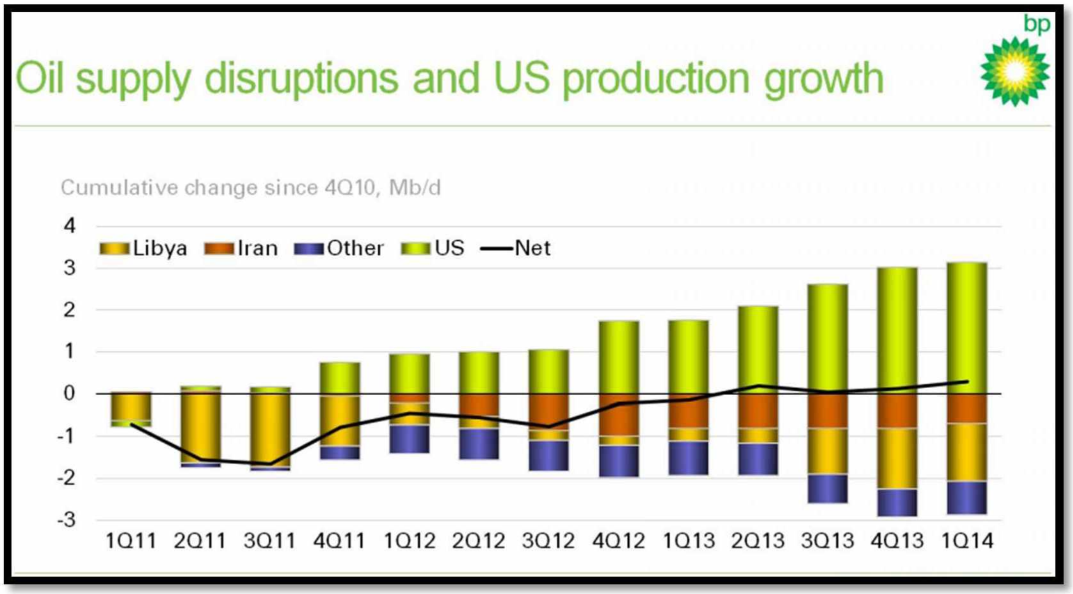


Fig 1. Oil Supply Disruptions and US Production Growth. 2013 BP Statistical Review. British Petroleum, 2014.

Eventually, supply disruptions did decrease. From the presentation of the 2014 BP Statistical Review, "That balancing act came to an abrupt end last year. The exceptional growth in non-OPEC supply far exceeded incremental supply disruptions." As supply far outpaced demand in late 2014, crude oil prices went into freefall.

Seeds of its own destruction?

With many experts claiming that shale production requires higher oil prices to be economic, some have thought that the price crash triggered by the shale revolution will be its own demise. Indeed, by keeping production levels steady OPEC has banked on it. Still others claim that the shale industry has "consistently outperformed projections and could do so again" (BP energy outlook 2035). So the question remains, will U.S. shale oil continue to revolutionize the energy industry or is it another short-lived boom? With its effects spreading to energy explorers, producers, consumers, and governing agencies around the world, this is an important question.

To answer this question, it is important to look at the factors that led to the energy market we have today and gauge if they will still be relevant in the future. This analysis will focus on three major factors that led to the shale revolution: technology, infrastructure, and crude oil prices.

Technology

The locations of shale formations in the US have been known for years. The problem is that oil producers did not know how to recover the oil economically. This is why the most commonly cited improvement that allowed for the shale revolution is technology. According to the Council on Foreign Relations, "The revolution is the product of advances in oil and natural gas production technology—notably, a new combination of horizontal drilling and hydraulic fracturing. These technological advances combined with high oil and gas prices have enabled increased production of the abundant oil and natural gas resources in the United States" (Brown, 2013).

While it is true that new directional (a.k.a. horizontal) drilling techniques and hydraulic fracturing played a large role in the shale revolution, there was another less well-known but equally important technology vital to shale's success: 3-D seismic mapping. While each of these technologies alone was not enough to cause major changes, their combination allowed for the transformation of an entire industry.

Hydraulic Fracturing

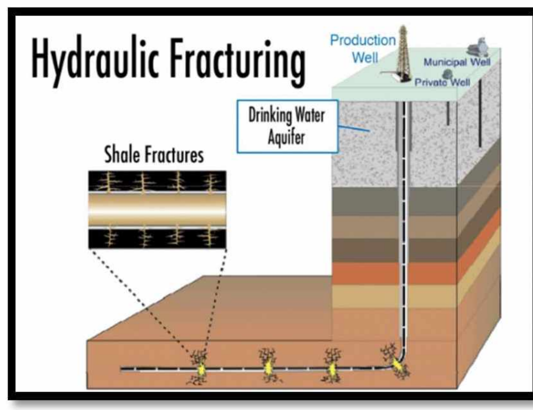


Fig 2. Hydraulic Fracturing. EPA.

Commonly referred to as "fracking," hydraulic fracturing is an oil and gas production technique where pressurized fluids are injected into shale rock formations to create fractures to release trapped resources. The process of developing a fracked well can take between three to six months and then can produce oil and natural gas for decades. When production is no longer economical, a well can be inexpensively capped off several feet below ground level leaving little evidence of production ever happening.

The successful development of a fracked well is an involved process. First a producer will drill a well into the targeted shale formation (typically over a mile deep). Once the formation is reached, the drill will then be turned horizontally to follow the formation for several thousand feet more (this will be described in more detail in a later subsection). Once drilling is complete, the well is fortified with steel casing and cement to strengthen the borehole wall and avoid issues such as contaminating ground water. Next, small perforations are shot through the casing into the shale rock along the horizontal section of the well. Finally, a fracking mixture containing mostly water(~90%), a little sand (~9.5%), and trace amounts of chemical additives (~0.5%) is pumped down the well at high pressures into the perforations; creating large factures in the rock. The sand from the mixture helps to hold open the fractures while the chemical additives play a variety of roles from lubrication to helping to move the sand. This final step is typically repeated several times along the horizontal section of the well. At this point, production begins and oil or natural gas naturally flows to the surface.

History of Fracking

A common misconception of the general public is that fracking is new. While there have been major advances in fracking technologies over the last decade, its origins date all the way back to 1860. It was at this time that people started experimenting with using dynamite to enhance oil production in their wells. While this process had some success, the first major fracking technology would come in 1865 with the "Roberts Torpedo" (fig 3).

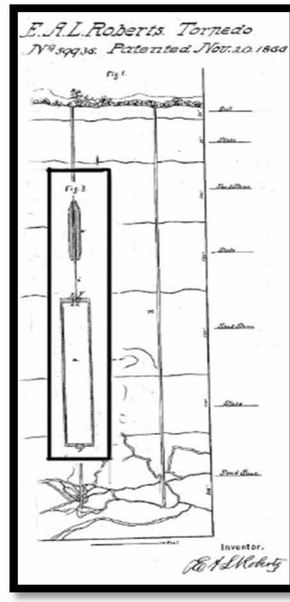


Fig 3. Roberts Torpedo Patent.

Edward Roberts was a Colonel in the Union army who led the charge in one of the Civil War's bloodiest battles: The Battle of Fredericksburg. During this attack, Col. Roberts was impressed by the destructive power of Confederate artillery rounds when they would land in a narrow canal that ran along the battlefield. This observation would later lead to one of the biggest innovations to the oil industry to that day.

His idea was to fill an oil well with water. Once that was done, he would lower an iron case filled with gunpowder (i.e. torpedo) to the correct depth. Finally, the torpedo would be detonated, with the water helping to concentrate the concussion in the correct spot. This method would consistently increase oil production by an estimated 1,000%.

The first true hydraulic fracturing experiment occurred in 1947 by Stanolind Oil and Gas Corporation (fig 4). While this experiment only utilized vertical drilling and used different fluids, it was very similar to how fracking is still done today. Three years later, Halliburton became the first company to create a commercially successful fracking operation. While fracking operations enjoyed some success at that time, they were short-lived due to major conventional oil finds a few years later (e.g. the Ghawar field in Saudi Arabia). Because these massive conventional oil fields were so much cheaper to produce, fracking would mostly disappear until the shale revolution.

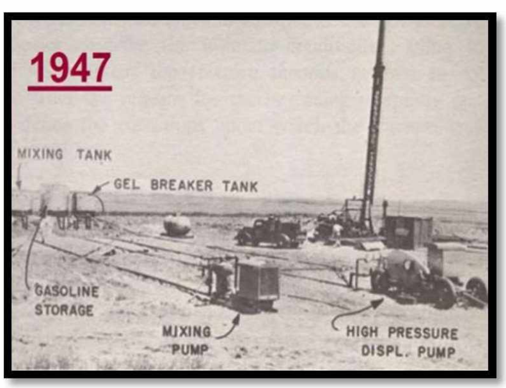


Fig 4. First Hydraulic fracturing stimulation at Hugoton Field. Cuadrilla.

Directional Drilling

Improved drilling technologies have allowed modern oil and gas wells to be drilled with a much greater degree of versatility and efficacy than ever before. This directional drilling technique, also commonly referred to as horizontal drilling, allows wells to be drilled in a variety of slants and directions. This method has many of benefits including a reduced drilling footprint, the ability to reach previously inaccessible areas, and greater target formation exposure.

History of Drilling

Traditionally, oil and gas wells have been drilled vertically. This was due in part to the simplicity of drilling a vertical well, but also due to a lack of geological understanding. In the early days of oil, the fact that oil reservoirs stretched horizontally was unknown.

It wasn’t until the end of the 1920’s that producers realized that their production dropped when wells were drilled by nearby competitors. This led not only to a number of lawsuits, but also to a better understanding of the nature of an oil field. A variety of survey techniques were developed to more precisely map out the size and shape of oil reservoirs. With this improved knowledge, it was becoming clear that the traditional vertical well may not always be the best option.

A number of experiments and incremental improvements to drilling technology would be made over the next several decades. The next major drilling innovation would come in the 1970’s with the downhole motor. Rather than spinning the entire drillstring from the surface, the downhole motor would be placed near the end of the shaft, causing only the drill-head to spin. This allowed for the shaft to be slightly curved near the drill head, causing a gradual change in the direction of the well.

Benefits of Directional Drilling

Directional drilling technologies not only helped make the shale revolution possible, but also transformed all types of drilling. The first major benefit of directional drilling is increased exposure to the target area. By drilling horizontally once a formation is reached, a well can now produce much more oil than a traditional well (fig 5). This also allows for far fewer wells to be drilled to fully develop a field.

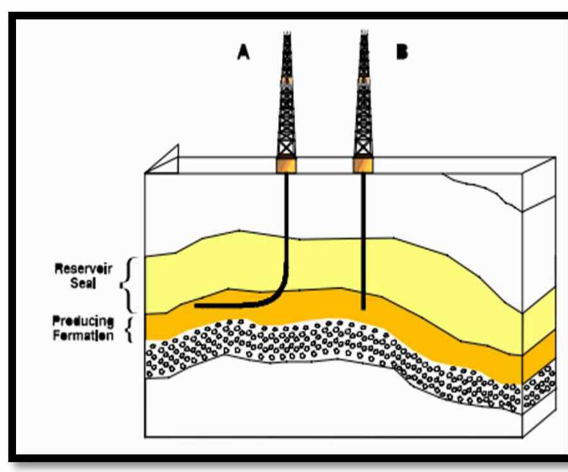


Fig 5. Horizontal Drilling. EIA. 1993.

The next major benefit is the ability to drill those fewer wells from the same pad. Historically, wells had to be spaced apart in order for them all to be productive. With directional drilling, the vertical portions of the well can be very close together because the horizontal sections will branch out going thousands of feet in different directions and depths (fig 6). This ability to consolidate pads leads to a reduction in property, capital, transportation, and environmental costs. Additionally, it makes drilling from places like offshore platforms much more economical.

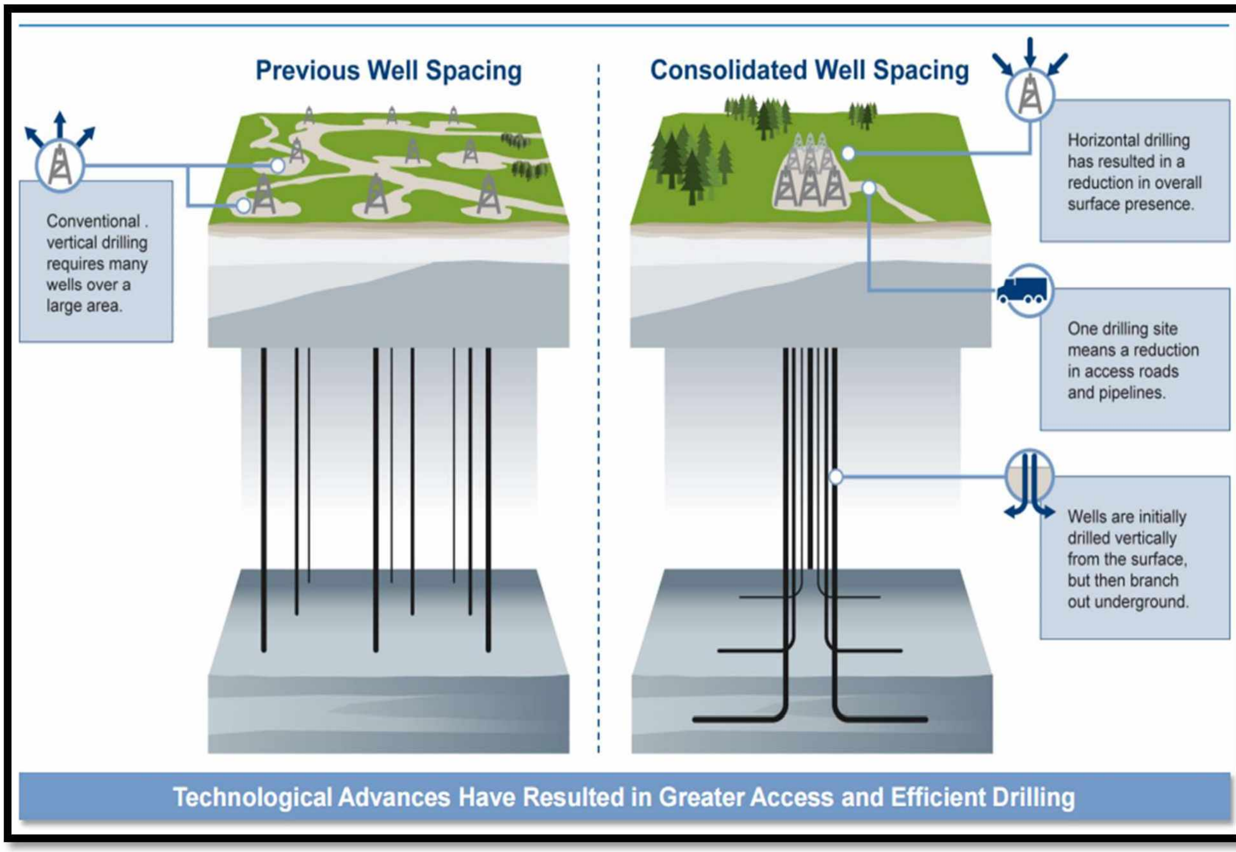


Fig 6. Technology Has Helped Unearth New Energy Opportunities. Asset Management. Goldman Sachs. 2015.

The last major benefit of directional drilling is the ability to reach formations or reservoirs that were previously unreachable. To give an example, if oil were located under a city the inhabitants might not be pleased with the idea of noisy drilling and production activities in the center of town. With directional drilling, the drill pad could be located on the outskirts of town allowing the residents to be at peace and the resource still to be developed (fig 7).

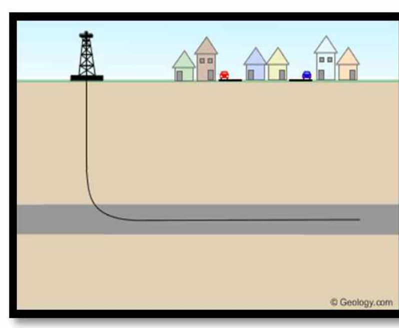


Fig 7. Target can't be reached by vertical drilling. Geology.com.

3D Seismic Mapping

With the massive increases in computing power, virtually every industry has been transformed. Commonly referred to as "big data," gathering vast amounts of data has been enhanced with the continued advancement in computing technology in recent years. Through a process called "data mining," sophisticated computer programs operated by field experts can interpret this data to unlock valuable information that was never before accessible. These techniques are now being applied to the oil and gas industry to help find better drilling opportunities and design better wells.

3D seismic mapping, or "seismic" as it is commonly referred to in the petroleum industry, involves creating a three-dimensional map of rock formations far below the surface. While the science behind seismic mapping is complicated, the process as a whole can be broken down to three basic parts: creating a shockwave, recording the reflected and refracted shockwaves, and interpreting the results.

Creating a Shockwave

The energy source used to create a shockwave varies depending on the terrain and location. Typically petroleum geophysicists will opt to use a "sudden shock" method. A common way to do this is to place explosive charges 20 to 250 feet below ground. Although simplistic, this method delivers a strong and effective shockwave. As an alternative to explosives, "thumper trucks" (fig 8) are sometimes used. These trucks will drop large weights against the ground to produce a similar result.

On flat terrain, seismic teams will frequently use a technique called Vibroseis. This involves placing a large metal plate onto the ground and vibrating it at a specific frequency. Rather than a sudden shock, this method creates smaller waves that are collected over longer periods of time. When the terrain allows it, this method is often preferred due to its minimal effect on the environment.

Fig 8. "thumper" trucks. Penn State News. May 10, 2013

Oceanic seismic mapping presents its own sets of problems. Due to the delicate marine ecosystem and the difficulty of getting equipment to the ocean floor, the previously mentioned methods for creating a shockwave are unavailable. As a solution, seismic teams will use a large vessel towing several air guns to fire bursts of air toward the ocean floor. While this method is considered safe to marine life, teams will sometimes utilize bursts with gradually increasing intensity to ward off marine life as an added precaution.

Fig 9. PGS Seismic Vessel. Offshore Energy Today. 2013.

Recording the Data

As a shockwave passes through the ground, much of it is reflected towards the surface. Properly capturing these reflected waves is the key to understanding what lies beneath. To do this, receivers need to be carefully placed in a surveyed grid over the entire area. These receivers record information such as the time it takes for the shockwave to reach the surface and the angle that it was reflected.

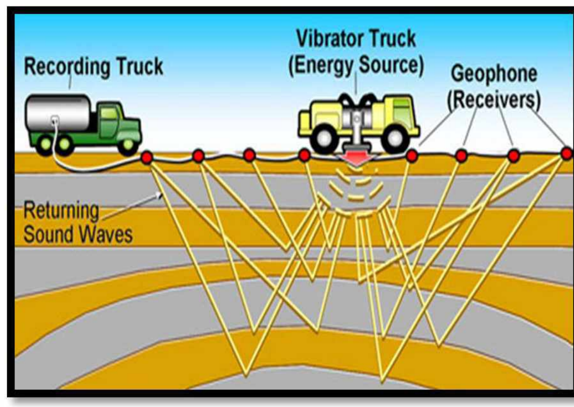


Fig 10. Seismic Study. Fayetteville Shale. University of Arkansas.

Oceanic seismic operations use the same basic idea, except the receivers are evenly spaced on floating streamers that are towed behind the air guns. For information to make sense, the vessel needs to be careful to remain at a constant speed and direction.

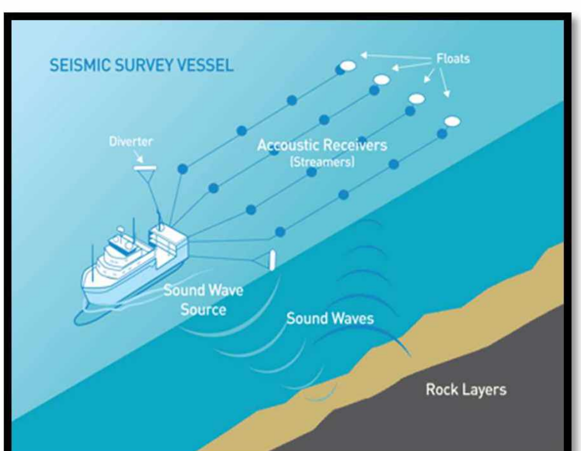


Fig 11. Seismic survey vessel. PG&E.

In either of these cases, receivers record massive amounts of data. For Exxon's mapping of the Kara Sea in Russia, approximately 75 terabytes of data were recorded. To put it in perspective, that is the equivalent of listening to about 17 years of music constantly. This massive amount of data would be nearly impossible to interpret without sophisticated computer programs; and even then it can be challenging.

Interpreting the Results

Measuring the time it takes for a reflected shockwave to reach the surface can give clues about what the shockwave had to pass through. This is because shockwaves will pass slower through higher density rock. While capturing a single reflected wave does not show much, capturing many will start to tell a story. Because waves are reflected from different depths, geologists can get an idea of several layers of strata. This might sound simple enough, but the vast amounts of data described above make this task extremely difficult. Generally this data is given to specialized companies who can work tirelessly for over a year before presenting results. In the end, the information gained is very valuable.

According to Rod Henson, Exxon's Drilling Operations Manager for Russia, "besides identifying exactly where to drill, 3D seismic ... helps us design the well better and helps us understand pressure risks so that we can drill the well safely and more efficiently." Combined with directional drilling technologies, 3D seismic mapping allows engineers to plan out exactly where formations need to be drilled and the best way to get there.

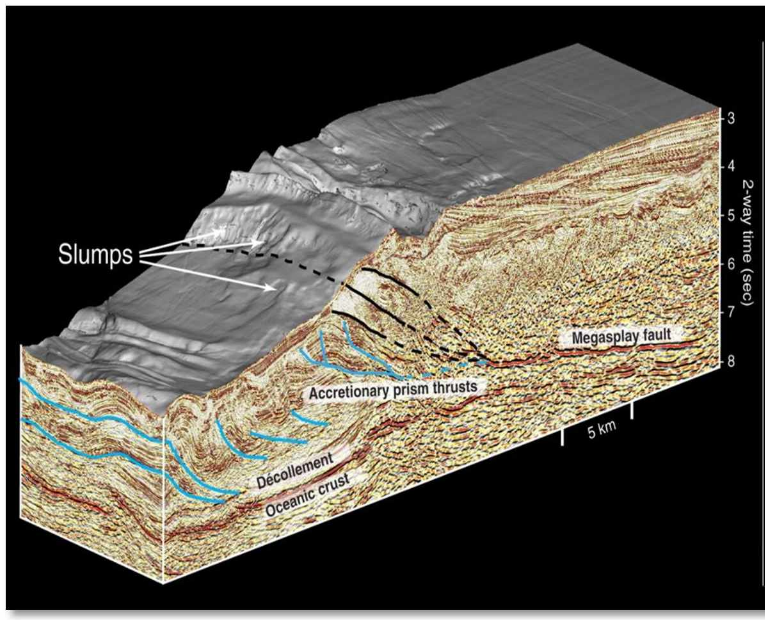


Fig 12. 3D Seismic Image. Wired. 2007.

The Birth of a Revolution

All of the key technologies were in place, yet the birth of the shale revolution still required one more ingredient: a man who was willing to risk everything. George Mitchell was one of the most powerful natural-gas players in Texas during the 1980s. By the mid-1990s, his wells were beginning to dry up. As it became clear that Mitchell would need to try something radical to survive, he turned his attention to shale. Up to this point, frackers had managed to retrieve resources from above and below shale formations but no one had come close to unlocking the trapped oil and gas inside of the shale formation itself.

After many failed experiments, George Mitchell started to receive heavy criticism for wasting money and his company stock prices began to tank. As his financial future was beginning to look grim, he considered throwing in the towel. Finally, in 1997, George Mitchell discovered the breakthrough that he needed. Like many scientific discoveries in the past, this one began with a mistake.

George Mitchell

At this time, fracking fluids consisted of expensive mixtures of gels or foams. During one test fracking operation, George noticed that the correct mixture was not being used. Instead, the fracking fluid being used consisted of mostly water. Rather than halt operations, he decided to see how it turned out. To his surprise, the well produced an impressive yield. Although most people wrote his success off as a fluke, his well continued to produce. He then started testing out his findings on other wells with similar results. Before long, this fracking technique would become standard and George Mitchell would be known as the father of the shale revolution.

Current/Future Developments

Since the birth of the shale revolution, drilling technologies have continued to evolve. According to Goldman Sachs head of Oil & Gas Damien Courvalin in his oil price presentation "New Oil Order," the shale industry is still in its infancy and has not enjoyed the cost-efficient standardization that occurs in more mature oil markets. In his view, shale oil will continue to get cheaper as these new technologies are developed. And indeed these technologies are being developed with several new innovations happening every year. Among the most groundbreaking of these innovations is the rotary steerable system and measurements while drilling.

Rotary Steerable System (RSS)

While the previously mentioned downhole motor was a major improvement that was necessary to make horizontal drilling possible, it is now being phased out by rotary steerable systems. Instead of having a curved shaft that must be oriented in the right direction, RSS uses a "push-the-bit" method that allows the drilling direction to be adjusted while drilling.

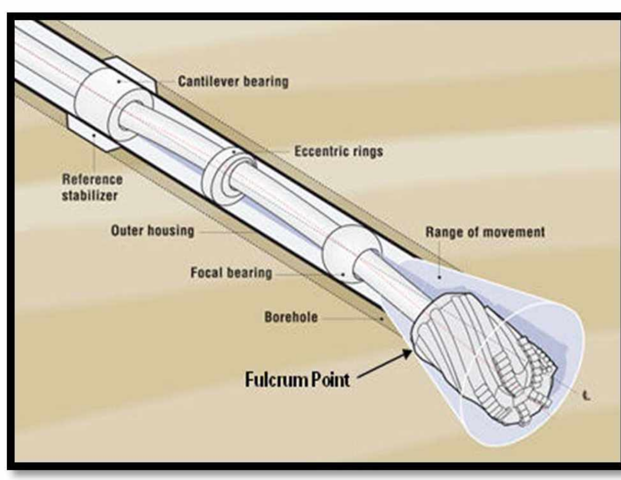


Fig 13. Rotary Steerable System. ASME. 2014

To accomplish this, an RSS system has two major components: an outer housing with stabilizing fins that grip the rock to keep it from spinning, and an internal rotating drill string with hydraulic pads that orient the bit by tweaking the drill string in different directions. Because this system is powered by rotating the entire drill string from the surface with a large engine rather than using a much smaller downhole motor, the rate of penetration is much greater. According to *Nontechnical Guild to Petroleum Geology, Exploration, Drilling and Production* "because it does not use sliding mode, it produces a smother wellbore and it provides for more constant steering" (296).

Measurements While Drilling (MWD)

By fitting gyroscopes, magnetometers, and accelerometers near the drill bit, a driller can get instant readings on the bit's location and orientation. By fitting a variety of different sensors, a driller can also get feedback about the surrounding rock. With a process known as fluid pulse telemetry, this data can be sent back to the surface through digitally coding pressure pulses in the drilling mud. By combining MWD and RSS, a driller is allowed to continuously adjust the direction to stay within the target formation.

These technologies also have implications outside of the shale industry. Both MWD and RSS are becoming standard for conventional drilling. With drillers now able to hit multiple targets with one well, marginal finds can be more cost effective to go after. These techniques might prove crucial for new fields on Alaska's North Slope such as Pikka, where a massive amount of oil is spread out between smaller deposits.

Future Developments

Technology gets better over time. The major discoveries of the past that made shale oil production possible will likely continue to improve making shale oil production more efficient. The current low price environment only helps to accelerate this process. With many of the current shale plays operating at below breakeven prices, there are many billionaire entrepreneurs who risk losing everything if they cannot come up with a solution. This adapt-to-survive setting created the George Mitchells and John Rockefellers of the past.

The other side of technology is obsolescence. As technology advances, there is always the chance that new discoveries might replace oil shale altogether. There are currently companies that show promise in creating a bacteria that turns waste into refined crude oil (Kelland, 2014). A breakthrough in other energy technologies could end our dependence on hydrocarbon fuel altogether. According to Sheik Yamani, Saudi Arabia's former oil minister and a founding architect of OPEC, "The Stone Age came to an end not for a lack of stones, and the oil age will end, but not for a lack of oil." While technology may aid shale right now, eventually it will replace it.

Infrastructure

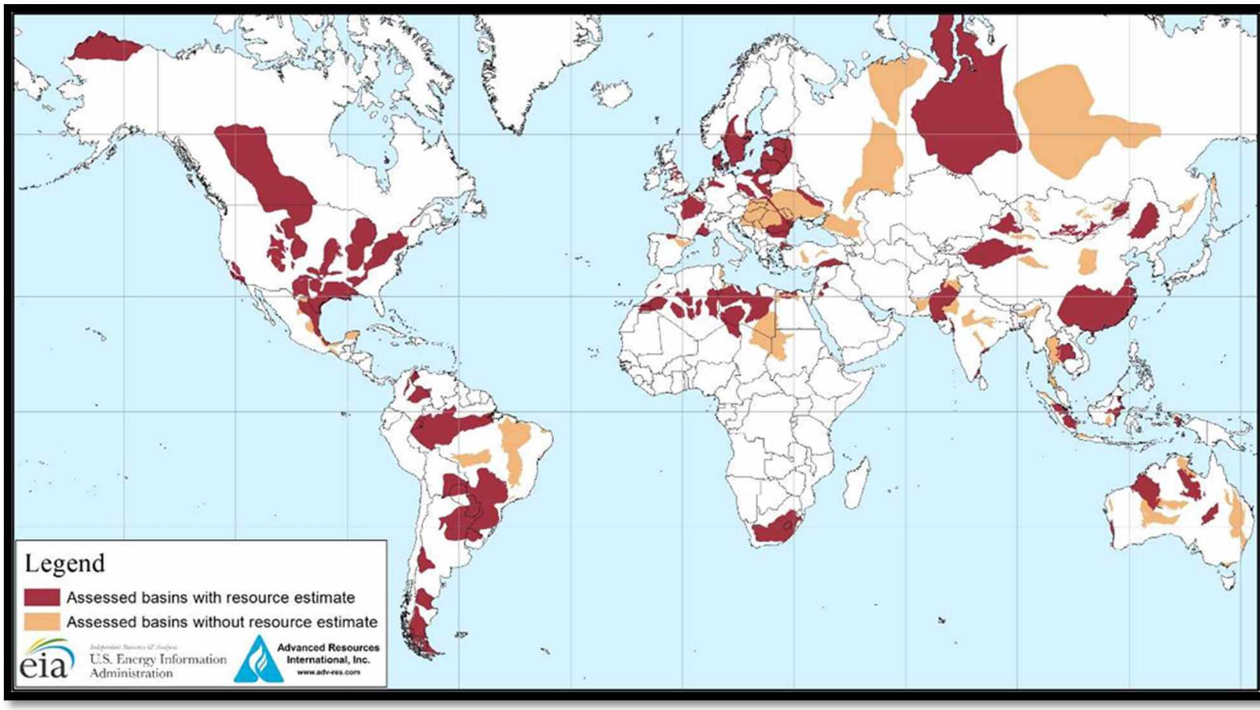


Fig 14. Assessed resource basin map. EIA. 2015.

Shale resources are located all around the world. It is clear from figure 14 that there are far more shale opportunities outside of the United States than inside. According to the Goldman Sachs "North American Shale Revolution & Energy Infrastructure Portfolio," Russia alone has over 60% more recoverable shale oil than the United States. So why did the revolution happen here and why was the rest of the world relatively untouched? The answer is infrastructure.

The successful development of a shale play requires much more than drilling for a few wells. A country must be politically stable. An entrepreneur must be able to finance operations. Finally, a country must be able to satisfy the capital and logistical requirements for development. As will be explained below, these factors made the United States a prime location for large scale shale development.

Recoverable Shale Oil Resources (Billion Barrels)

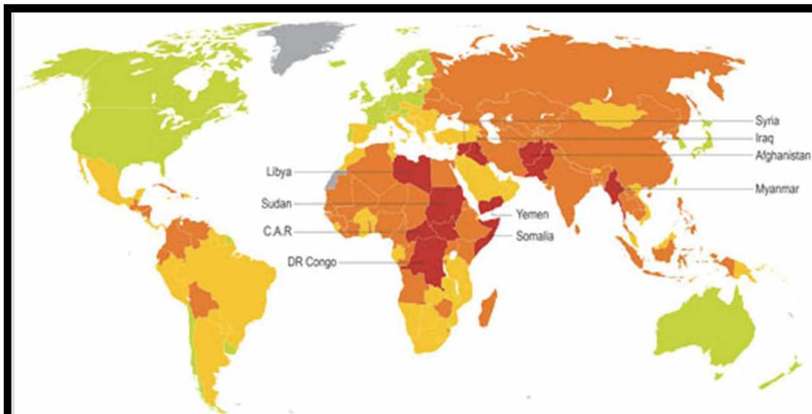
1	Russia	75
2	**US**	**48**
3	China	32
4	Argentina	27
5	Libya	26
6	Australia	18
7	Venezuela	13
8	Mexico	13
9	Pakistan	9
10	Canada	9
11	Others	65
	TOTAL	335

Fig 15. Recoverable Shale Oil Resources. North American Shale Revolution & Energy Portfolio. Goldman Sachs. 2014.

Political Risk

Political risk is a major concern for oil producers. While there is always risk of a government passing laws to limit economic activities, the real fear is of an unstable government nationalizing private assets. For this reason, many countries that are very rich in natural resources are extremely underdeveloped. As the book *Energy: The Master Resource* notes, “In free societies, where life, liberty and property are protected, people have much greater incentive to create wealth, because such protections ensure that people control and benefit from the fruits of their own labors” (128). Capital spending on oil production can total in the billions and investors want to be sure they can reap the profits of their own efforts.

Because of these risks, companies (or consultants) routinely do studies on the stability of different governments to help determine investment options. Figure 16 is an example of one such study. When this map is compared to the world-wide shale resource map in figure 15, it starts to shed light on one of the major reasons the shale revolution was so exclusive to the United States.



Legend		Rank	Country	Rating	Rank	Country	Rating
Extreme risk	■	1	Somalia	Extreme	6	Iraq	Extreme
High risk	■	2	DR Congo	Extreme	7	Libya	Extreme
Medium risk	■	3	Sudan	Extreme	8	C.A.R	Extreme
Low risk	■	4	Afghanistan	Extreme	9	Syria	Extreme
No Data	■	5	Myanmar	Extreme	10	Yemen	Extreme

Fig 16. Political Risk (Dynamic) Index 2013. Maplecroft. 2013.

Financial Markets

The United States economy runs on finance. The ability of entrepreneurs to receive financing from banks or investors is crucial to economic growth. According to the *Financial Times*, “financial markets were as critical to the US shale boom as the industry’s knowledge base, the ownership of mineral rights, the installed infrastructure or supportive government regulation” (Crooks, 2015).

The well-established United States financial markets allowed for wildcatters to raise the funds they needed to develop shale operations. From the Financial Times, “The US exploration and production sector raised $95 [billion] in equity, $206 [billion] in bonds and $574 [billion] in syndicated loans" from 2007 to 2014 (Crooks, 2015). Without this financing, the shale revolution would have been much smaller in magnitude.

Over-Investment

While financial markets were crucial to the rapid growth of shale production, artificially low interest rates set by the Federal Reserve played a major role in its crash. This is because companies have an incentive to borrow when interest rates are low. Generally, low interest rates are an outcome of a large supply of money due to increased consumer savings. When the interest rates are artificially set, companies increase borrowing while consumers actually save less due to the decreased yields from savings. This creates an environment of over investment that cannot be supported by future consumer spending. With the oversupply of oil and low crude oil prices, lenders and investors are fearful that many of these shale operations will go under. Most analysts believe that shale production financing will taper off sharply during this time of uncertainty. Even if prices recover, it is doubtful that shale investments will continue with the same energy that they enjoyed in the past.

Capital Infrastructure

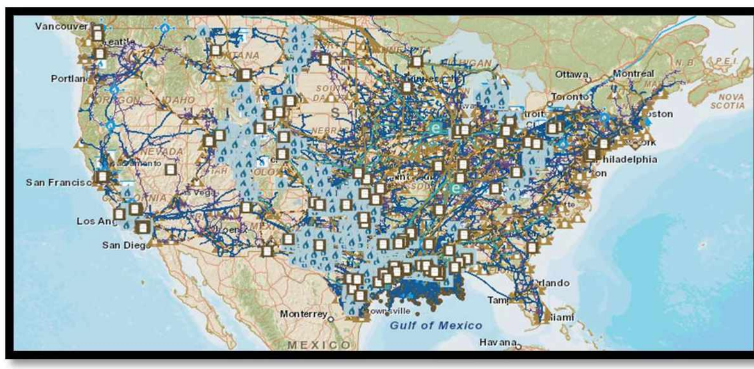


Fig 17. U.S. Energy Mapping System. EIA. 2015

Developing a shale play can be costly and requires far more than drilling a few wells. The location must be accessible in order to bring in the equipment necessary to drill a well. Once a well is in production, there must be infrastructure in place to transport the oil – whether it be via pipeline, railroad, shipping, or trucking. The oil must be transported to a refinery that is tooled to handle the specific gravity and viscosity of oil being produced. Refined products then need to be able to reach the customer.

With approximately 2.5 million miles of pipeline, 140 thousand miles of rail with 136 crude oil terminals, and 2.65 million miles of paved road all connecting to 142 refineries and 493 natural gas processing plants, the United States is in a perfect position to meet this challenge. Having developed supporting industries, a specialized labor pool, and large customer base makes the US especially attractive to producers. As this capital infrastructure continues to grow, the United States will continue to be a top choice for shale development.

Crude Prices

High crude oil prices played a big role in the shale revolution. This is because fracking was much more expensive than conventional oil production. While conventional oil production can continue to be profitable at low prices, fracking operations may lose money. With prices consistently hovering around $100 per bbl since 2010, shale production promised to be very profitable. With the price crash in late 2014, however, many of these developments are at risk.

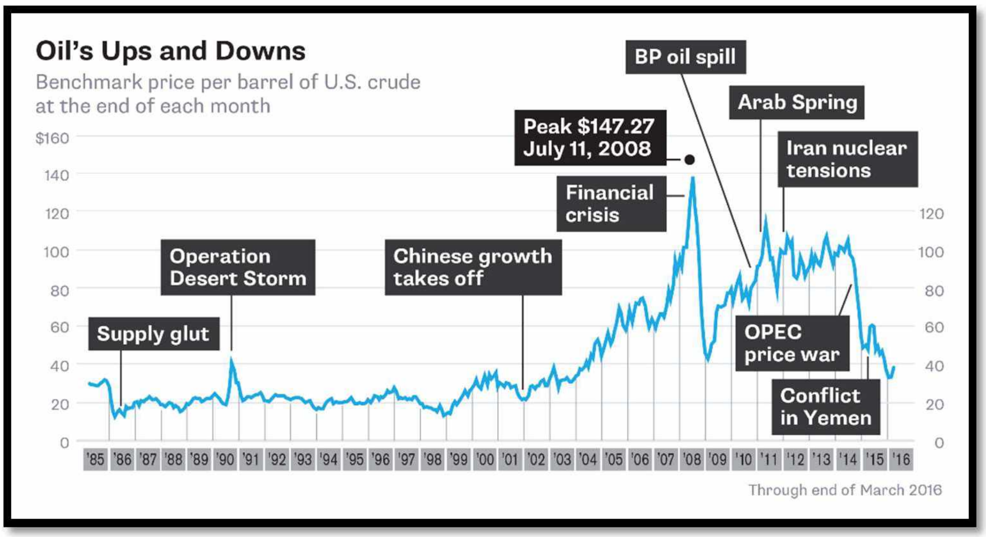


Fig 18. Oil's Ups and Downs. Oil Prices. Bloomberg. March, 2016.

The Price Crash

To understand the price crash, it is important to understand why crude oil prices were relatively high to begin with. At a basic level, prices will increase when demand exceeds supply. Figure 18 shows a piece of the puzzle. While oil consumption in the West (OECD) has gradually been falling each year, Non-OECD countries (primarily China and India) have been experiencing rapid growth. This growth has more than offset the small decline from OECD countries yielding a net increase in consumption each year.

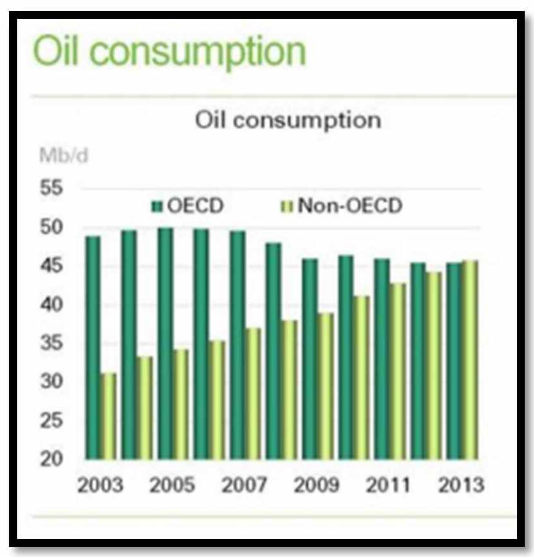


Fig 19. Oil Consumption. 2014 BP Statistical Review. BP, 2015.

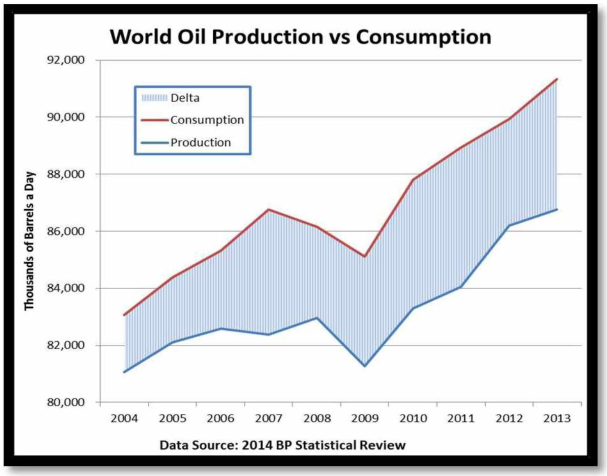


Fig 20. World Oil Production vs Consumption.

While world demand was steadily growing, increases in oil supply were not able to keep up. Figure 20 shows how the delta between world production and consumption was steadily increasing up to 2013. This gap was continuing to widen despite the massive increase in oil production from the shale revolution. This trend may have lulled US oil producers into a false sense of security.

Although US oil production was rapidly increasing, its effects on oil prices were being masked by major disruptions elsewhere in the world.

As interrupted operations would come back online throughout 2014, the market was flooded with excess supply. At the same time, demand growth from places like China were less than expected. These factors led to a sharp decrease in prices. As the world looked to OPEC – and specifically Saudi Arabia – to cut oil production in order to stabilize prices, OPEC did nothing. Rather than cut production and risk losing market share, Saudi Arabia decided that it was in a good position to outlast the more expensive shale production in a price war. This caused crude oil prices to spiral downward.

Breakeven Prices

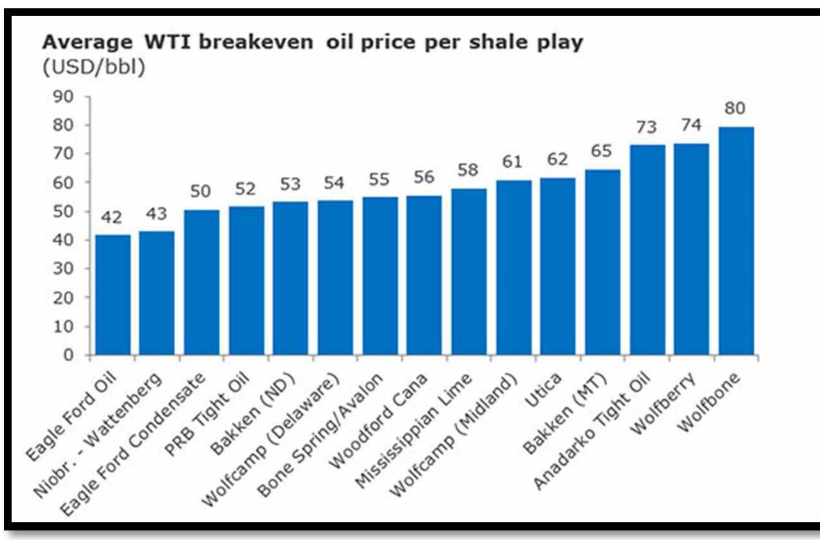


Fig 21. Average WTI breakeven oil price per shale play. NASReport. Rystad Energy. 2014.

As price takers, oil producers are vulnerable to price drops. A breakeven point is a price where a company's operation neither makes nor loses money; a company will enjoy a profit at any price above this point, and a loss at any price below it. Figure 21 shows the approximate breakeven prices for many shale plays in the United States. It should be noted that at current prices, operations are below their breakeven points. While companies may continue to produce at a loss in the short term, many will face bankruptcy in the long run if prices do not rally or if costs can't be reduced.

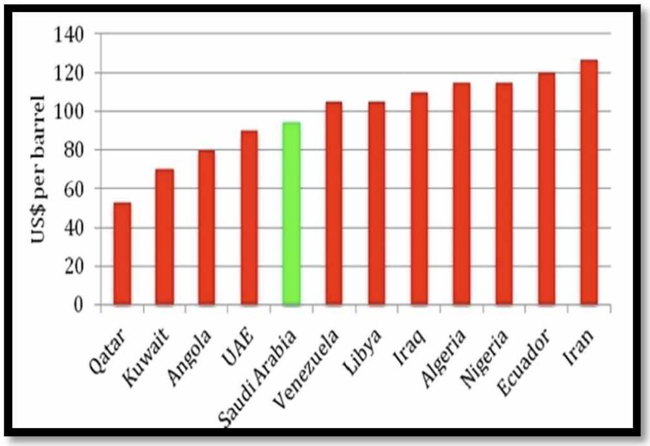


Fig 22. OPEC median budgetary breakeven price. Real Clear Energy. October 20, 2012.

Another breakeven point to consider is the budgetary breakeven prices for OPEC. Saudi Arabia has the cheapest oil to produce in the world and is profitable above about $25 per bbl. However, their government depends on oil revenues which requires them to need higher prices. It is estimated that to keep from running at a deficit, they need prices to be around $95 per bbl. While they have considerable financial reserves, eventually Saudi Arabia will need prices to rise.

Future Prices

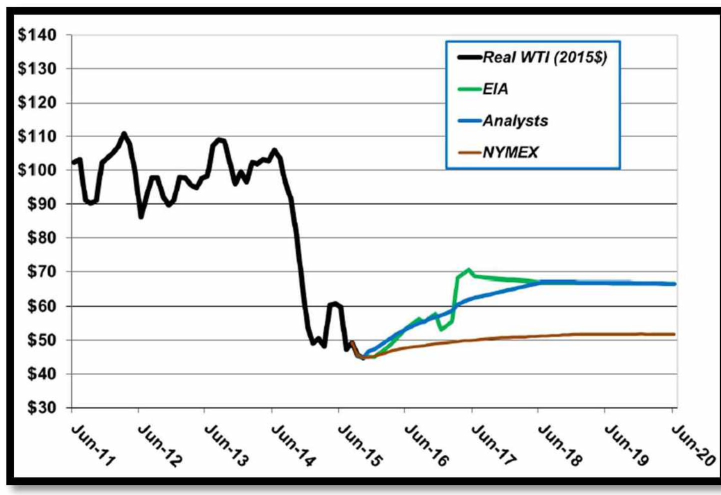


Fig 23. WTI Price Forecast. Crude Oil Forecasts. Alaska DOR. 2015.

Most analysts believe that oil prices will recover at least somewhat. There are several factors that may play a role in this recovery. At current price levels, many new operations will be delayed and even some current operations may be suspended. The resulting decrease in supply will help to stabilize prices at a higher level. Also, if prices remain low for long enough, OPEC could be pressured to reduce production in order to drive up prices again.

On the demand side, lower prices help to increase oil consumption. This is especially true in countries like the United States where decreased energy costs prop up economic growth – further increasing demand. This increase in demand, along with the previously described possible reductions in supply, should help prices to recover to some extent.

As a final note, we are unlikely to see crude oil prices at the previous $100 norm any time soon. While prices are expected to rise, shale oil production can be ramped up relatively quickly as it becomes profitable. Although unforeseen geopolitical issues may cause temporary jumps in equilibrium prices, under normal circumstances, shale oil will probably create a price ceiling well below $100.

Alaska

The most substantial effect that the shale revolution has had on Alaska is in the form of low crude oil prices. With such a large percentage of Alaska's economy coming from the oil industry, Alaska has been hit harder than any other state. With the days of $100 behind us, the Alaska Legislature has begun to look into other revenue measures like taxing new industries, creating an income tax, and drawing from the Permanent Fund. While each of these options may help to close the state budget deficit, they will cause additional harm to the private sector. According to Erickson & Associates, "Unless oil prices recover, Alaska is headed for the deepest recession in its modern history, and one of the deepest regional recessions in modern American experience" (Erickson - 20).

As gloomy as the situation looks for Alaska, the shale revolution has had some benifits. Though Alaska has not had any shale development, new shale technologies provide value to conventional production. If prices do eventually climb as predicted, these technologies will allow Alaskan producers to target many of the marginal oil deposits that were not economical to produce before. For example, Alaska's North Slope has massive amounts of oil that is spread out between smaller deposits that could be profitable with the use of rotary steerable system and measurements while drilling technologies. Depending on how high prices eventually climb, and any new efficiencies that might make drilling more cost-effective, these technologies might just be what Alaska needs to eventually reverse the North Slope oil decline.

Finally, one major long term benefit to Alaska may come in the form of shale development itself. While there has not yet been any shale development in Alaska, there is a massive shale formation on the North Slope. According the USGS estimates this formation may contain up to 2 billion barrels of recoverable oil. In 2010, Great Bear Petroleum LLC acquired a lease for 500,000 acres to take advantage of this find. Unfortunately due to the price collapse and other logistic concerns, this area was not developed. Low prices aside, Alaska lacks much of the infrastructure necessary to effectively produce a shale play of this size. When comparing figure 17 to figure 24, this becomes clearer. That being said, at least one company thought Alaska shale development could be profitable at around $100 per barrel. As prices rise and technology continues to lower breakeven prices, Alaska shale may eventually be developed.

Fig 24. U.S. Energy Mapping System. EIA. 2015

Conclusion

Technology has played a large role in the shale revolution. Advances in hydraulic fracturing, horizontal drilling techniques, and 3D seismic mapping have made it all possible. While better technologies might eventually replace shale oil, improvements will continue to advance the shale revolution in the foreseeable future. Indirectly, the capabilities created by these advances will have a positive impact on Alaska.

The shale revolution is primarily focused in the continental United States. This is mostly due to the vast amounts of infrastructure that the U.S. enjoys. With a very high degree of political stability, well defined property rights, strong financial markets, and massive amounts of supporting capital in place, the United States is an attractive choice for shale operations. Someday, with price increases and better infrastructure, shale may even be possible in Alaska.

Although the previously mentioned indicators show that shale has a bright future, crude oil prices are an area of uncertainty. Some shale operations are profitable even now but many other operations are currently running at a loss. If prices do not increase above current levels, many companies will probably go under. While most analysts believe that prices will eventually climb, it is unlikely they will reach previous levels.

After considering all the evidence presented, I would consider shale's future bright. Although it is unlikely that it will experience growth as strong as it was pre-2014, several factors that led to the shale revolution are poised to improve from current levels. With the end of the shale nowhere in sight, it remains to be seen if Alaska can recover from its current problems and figure out a way to leverage the shale revolution's success. Although the situation currently looks bleak, there is still a lot of promise for Alaska. With a little adaptation, Alaska's future can be just as bright as shale's.

Fig 25. Shale Oil Platform. Seal, Eddie. Getty Images.

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