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Re-fracking

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Abstract- The past two years have been a difficult ride for the investors worldwide and world's biggest publicly traded oil companies. As compared with their high-hall marks set in mid-2014, Big Oilcompany's shares are down about 25% and profits in terms of earnings have been collapsed.Despite of 50% decline in oil price, Big Oil is still getting bigger. In July 2014, U.S. oil production was around 8.75 million barrels per day, according to the Energy Information Administration. Nearly a year (50% price decline) later, U.S. oil output was increased up to 9.69 million bpd, reachingits highest level in past 45 years.
The declining crude oil prices have been putting the exploration and production companies' finances under pressure. The companies are looking for new technologies to boost operational and financial efficiencies. Refracking is fast emerging as preferred technologies for companies engaged in shale based activities to boost production with low cost.

I. CHANGE IN US OIL AND GAS MARKET SINCE 2000

Global oil price movements are subject to market factors, mainly the balance of supply and demand, the macroeconomic and geopolitical situation, the dynamics of the US dollar exchange rate and situation of the global financial markets. Technological breakthroughs have made it possible to develop huge resources. The increase in unconventional oil and gas production in the US served as a good example. The US oil production increasesforced many analytical agencies to lower their long-term oil price forecasts. With the same time a number of trends will support oil prices in the medium term. In this we would like to specify few of trends/reasons and critically analyse a number of challenges that the oil industry are facing now--days and these played a vital role in changing US oil and gas market since 2000.

II.SHALE GAS MARKET

Shale gas in the United States grew rapidly due to the extensive increaseinavailability of natural gas. Driven by the introduction of hydraulic fracturing technology and horizontal drilling,increased shale based activities led to major increases in reserves of US natural gas. Mostly due to discoveries of shale gas, estimation of reserves of natural gas grew gas in the United States in the year 2008 which was 35% higher than in the year 2006.

In 2007, shale gas fields also included the (Barnett/Newark East) and around thirteen (Antrim) sources of natural gas in the United States in terms of gas volumes produced.The number of wells of natural gas in US has increased from 18,485 approx. to 25,145 in 2007 approxwhich was expected to continue grow in numbers until about 2040 compared to conventional wells

The economic viability and success rate of shale gas in the United States since 2000 influenced positively towards the rapid development of shale gas in Canada, and, more recently, has spurred interest inEurope, Asia, and Australia.

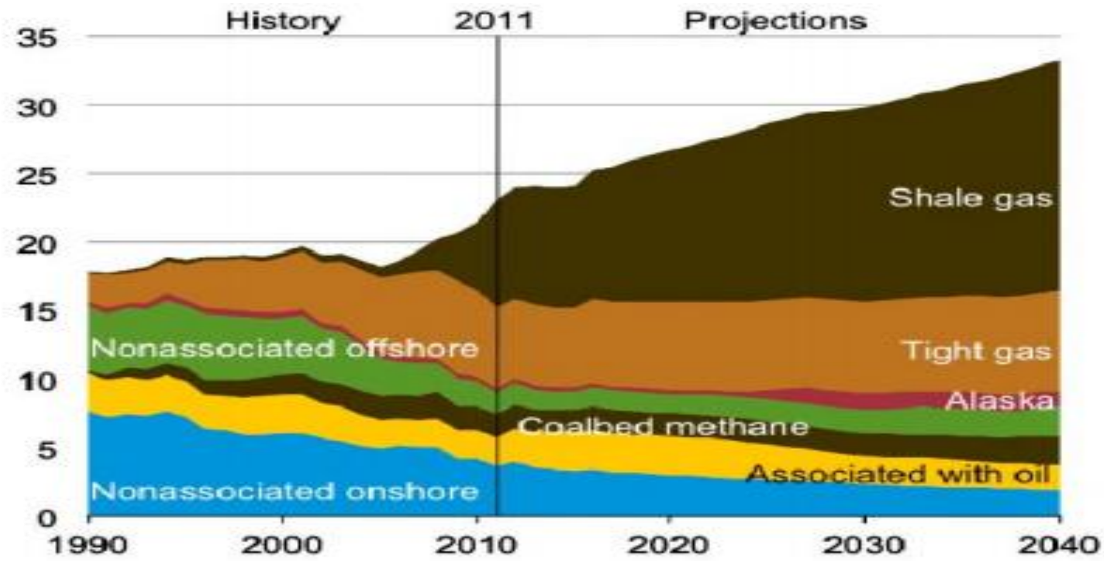
It has been deduced that there can be a 100-year supply of natural gas in United States, but the figures practically shown in proved reserves were of much difference.After 2007, the United States' natural gas industry has experienced a significant transformation, which was foreseen as 'revolution' extraction rates have increased and all the credit goes to new technologies. The shale gas boom is having an affect which the market hasnever experienced by the US energy market, and this, in return, hasimportant implications for the rest of the world, especiallyfor the Middle East and Russia.

While the shale gas 'revolution' has created environment of a debate in regards to the environmental consequences and sustainability within the US. Whereas countries such as Canada and China tried different ways to replicate the US boom. In the European Union, a shale gas 'revolution' appeared relatively negative during that timespan, at least for that moment, because Europe showed less favourable geological conditions. Nevertheless, some EU

Member States rich in shale gas, such as Poland and the United Kingdom, were actively promoting shale gas exploration activities to diversify their energy mix, and reduce energy dependency to have better energy security at the same time few countries, such as France and Bulgaria, have chosen to privilege environmental constraints and have implemented bans. The remaining other seem to have adopted a 'wait-and-watch' attitude. Slowly it created and great impact in the Gas market.

The United States natural gas industry has created a 'revolution', the innovative technologies holds the credit. Investments in new extraction techniques drilling horizontal wells and hydraulic fracturing techniques have made gas production a less expensive commodity. Fracturing technology hascreated an access to vast resources of unconventional gas, specially 'shale gas', which is found trapped within sedimentary shale rock formations and which is extracted by injecting sand, chemicals and water at high pressure.

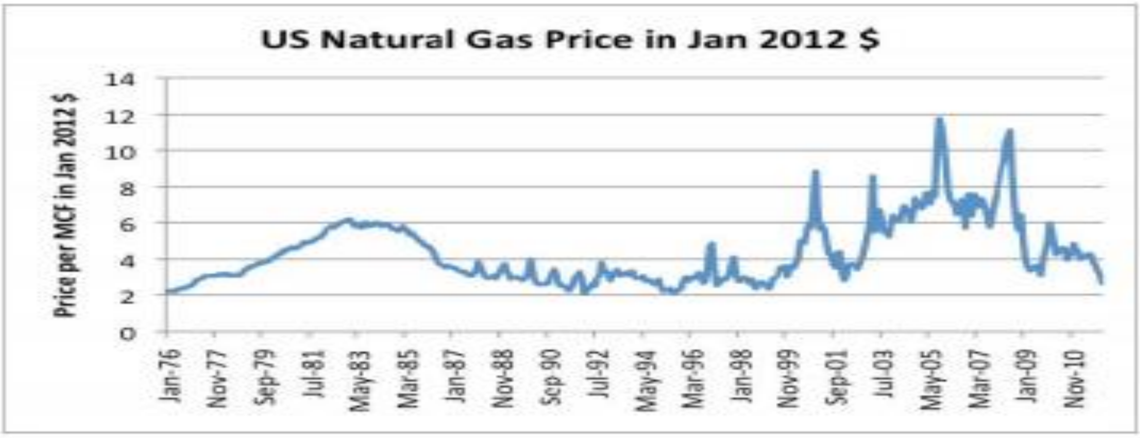
Fig 1- U.S. Dry natural gas production



The shale gas buzz, combined with ease access to new and vast natural gas reserves and supplies, has led the US shale gas production to soar at its peak dramatically since 2007. By 2010 shale gas started holding an important place in the US Energy mix, Shale gas constituted 23 % of US gas production, it was an undefined change from the previous year production. It was a period when it only contributed 14% of the total country's gas production. The US Energy Information Administration's Annual Energy Report predicted that the US natural gas production will increase from 23.0 trillion cubic feet (tcf) in 2011 to 33.1 tcf in 2040 a 44 % increase. This increase is largely due to the anticipated growth in shale gas production, which was expected to grow from 7.8 tcf in 2011 to 16.7 tcf in 2040.

There is a hugedeposits of unconventional gas which are located across the US. The most important field including the Barnett reservoir in Texas and the Marcellus reservoir, which run across New York, Pennsylvania and most of the Western Virginia. The Barnett reservoir first startedits production in the late 1990s and represents one of the most established fields in the US.

Fig 2- U.S. Natural Gas Price in Jan 2012 $



Source: EIA

Now, thoughUS continues to import millions of barrels of crude oil per day, but it has been observed that from 2005 the country's dependence on oil import has declined noticeablyfrom 60 % to 39 % it due to shale gas. The United States appeared to be self-sufficient in its own best waysince oil and gas and has decrease its supply from Saudi Arabia as the world's bigger supplier of hydrocarbons by 2020 it may stop completely forcing the middles east country the oil cartels finding new market. Already, the country's increased production is having an adverse impact on the rest of the oil producing countries specially OPEC countries world.

What does shale gas do to the energy market? Consider the following just to start with

- It adds more supply to the already well supplied gas market which is creating a situation were more supply is there creating a glut situation in the market. Current contracts for natural gas supplies are linked with the oil prices, which has shredded deeply. Now, there is a gas to gas completion which will intensify.
- The current scenario is having an adverse effect on the market and raising question mark for the expensive billion dollar projects for natural gas and LNG projects keeping the investors' money on stake. Few projects are kept on hold and few have been already cancelled and several more to come up with the closing of the projects, for instance-Australia is looking very vulnerable for their LNG project.
- The shale gas change the geography of the world market, as US was one of the highest importer is now soon to come into the category of exporter. China is trying to develop its own supplies and future imports could be much lower than current imports as predicted.
- Russia is losing its market share, especially in Europe and as a result Russia is coming up with new policy such as LOOK EAST POLICY.
- Shale is also holding a knock out effect .Cheap gas has started to showcase displacement in coal demand in the US power generation market pushing coal exports into Europe at lower prices.

III. Shale Oil Revolution and its impact on the global market

Saudi Arabia and other major OPEC producers need oil prices on an average of $95/barrelto sustain its extra expenses.On other hand U.S. shale development requires $72-$80/barrel to break even, due to the advancement in the technology.

As per International Energy Agency,the US may over take Saudi Arabia and Russia to become the world's biggest oil producers so as to call them as swing producers, by 2020 and they would be self-sufficient by 2030.

The scenario pertains for a longer time American shale oil production success rate increases possibility is that it may deny the OPEC power to set global oil prices and the world won't be the same in the wake of shale.

IV. Hydraulic fracturing

Hydraulic fracturing, or"fracking," involves the injectionof more than a million gallonsof water, sand and chemicalsat high pressure down andacross into horizontally drilledwells as far as 10,000 feetbelow the surface. Thepressurized mixture causes therock layer, in this case the Marcellus Shale, to crack.These fissures are held openby the sand particles so thatnatural gas from the shale can flow up the well.

History and evolution of Hydraulic Fracturing

In 1857, when Preston Barmore lowered gunpowder into a well at Canadaway Creek, NY, and dropped a red-hot iron down a tube, resulting in an explosion that fractured the rock and increased the flow of gas and oil from the well, called as fracturing.

In 1865, Col. Edward Roberts and his brother developed a technique known as 'superincumbent fluid-tamping', in which water dampened the explosion, preventing any debris blowing back up the hole and amplifying its effects. They also developed a nitro-glycerine 'torpedo', replacing the black powder and gunpowder that had previously been used.

In the 1940s, Floyd Farris of Stanolind Oil proposed that fracturing a rock formation through hydraulic pressure which may increase well productivity. This was followed in 1947 by the first application of the 'Hydrafrac' process at the No.1 Klepper well in the Hugoton Field, Kansas. One thousand gallons of palm oil (napalm) and naphthenic acid were combined with gasoline and sand to stimulate the flow of natural gas from a limestone formation.

In 1949, Halliburton Oil Well Cementing Company obtained an exclusive licence for the hydraulic fracturing process. In the first year of operations, 332 oil wells were treated with crude oil or a combination of crude oil, gasoline and sand. The wells on average increased production by 75%. From 1953, water was also used as a fracturing fluid, and various additives were tried to improve its performance. By 1968, fracking was being used in oil and gas wells across the United States.

V. What's next?

In Low oil price environment companies are not going ahead with the expansion plan and focusing more on increasing operational efficiency. Therefore,they are looking at technologies to boost production from the wells. One such technology,gaining prominence in boosting production is**Re-fracking**.

Re-fracking is the procedure of returning to older shale oil and gas wells that had been fracked in the past to capitalize on newer, more effective extraction technology. Re-fracking can be effective on especially tight deposits where the shale produces low yields to expand their productivity and life

Re-fracturing of shale wells is among hot topic since operators can apply the latest technique to older wells, which would result into increasing production without incurring all the other costs of a new well.

Comparative cost analysis

Fracking	**Re-fracking**
Cost of fracking a new well is around- \$8- \$12 million Cost breakup- • Rig and drilling fluid- 15% • Casing and cement- 11% • Frac Pumps, Equipment- 24% • Proppant- 14% • Completion fluids, flow back- 12%	Cost of re-fracking an old well is around- \$2 million Cost breakup- • Frac Pumps, Equipment • Proppant • Completion fluids, flow back

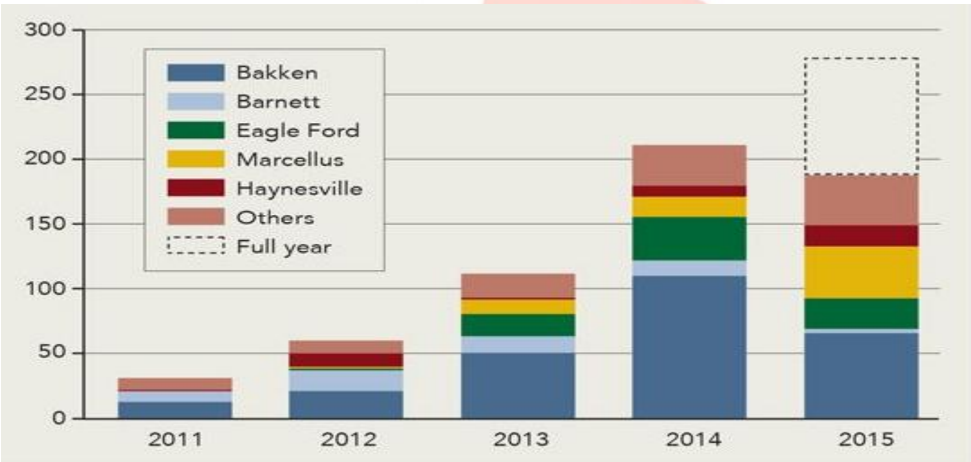
• Other- 23%	

But the question arises what is the success rate?

Operators are keen towards discussing the possibility of re-fracked wells in several different aspects, but how have the results compared to expectations so far?

To re-frac a well an operator goes into an old well, or underperforming well, stops the production and again completes the well with new hydraulic stimulation. As of August 2015, less than 1% of the total 100,000 horizontal wells in the United States have been re-fracked. Below fig shows the number of US wells re-fracked every year, by the year 2015, and the dotted line indicates the full year expected number. As compared to the overall drilling activity that had been decreased by 40% in 2015, now the companies are showing clear interest in re-frac opportunities as described in the below fig indicates a 30%increase. There have been few targeted re-fracks in almost all the places, but the majority of the activity has been observed in Bakken,Barnett and Eagle Ford.

Fig 3- No. of Re-fracked well in U.S.

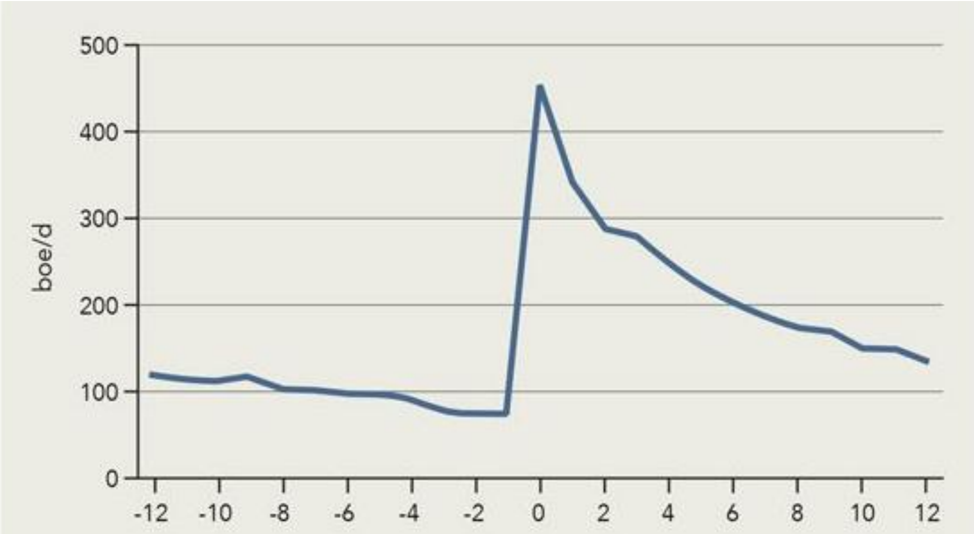


Source:Rystad Energy Analysis

The above graph only includes horizontal re-frac jobs; there has also been a significant increase for the re-fracking process for vertical wells, for example, re-fracked 150 vertical Barnett wells in 2015, where they report an average production increase of 700%.as per Deccan Energy.

Theoretically, the cost of a re-fracked well should be almost similar to the cost of completing the well. But on an average, about 1/3 of the development cost of a horizontal shale well goes to drilling, while the remaining 2/3 is allocated to completion. This underlines, by re-fracking an older well, operator can save the cost of drilling the well. Currently, the Bakken is the play with the largest number of re-fracked horizontal wells.

Fig 4- Increased production after re-fracking



Source:Rystad Energy

By examining the performance of the roughly 300 re-fracked wells, it is possible to quantify the success rate so far.By the Graph shown it can be depicted that production for the average Bakken shale play well, one year before and one year after recompletion. The x-axis shows the cumulative months from re-frac, with Zeroth month representing the first month of production. On an average, the process increases the production by more than four times after the new stimulation, with higher production throughout the entire first year.

By doing a comparative study of the additional production from re-fracs to the additional costs, it is possible to determine which method is more profitable. The development cost per barrel (EUR) for each well type is the values are based on the average capital expenditure per well, where the re-frac wells cost 2/3 of the total well cost. State data and operator specific decline curves are used to determine the cost. Since 2013, the average cost has decreased for both categories with the gap closing in 2015. If the same trend continues, then re-fracks may become a more profitable approach for operators.

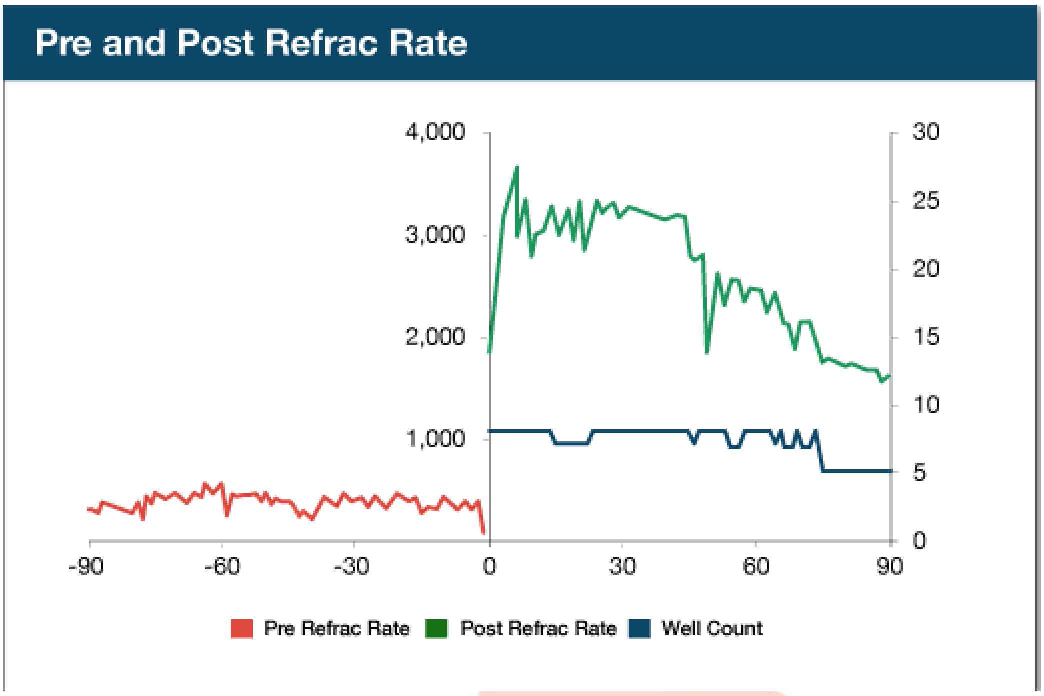
Re-fracking the older wells definitely increases the recovery of the well, but as per current results/data, it is generally more profitable for operators to drill a new well. Recompletion is still an immature recovery technique but once better results are replicable, re-fracked wells could holds a potential for low cost production.

The overall cost of drilling a new well, investing for building the necessary infrastructure and then fracking it might cost $8-12 million. Conversely, the cost of going into an existing well with all the required infrastructure in place and re-fracturing it with current best techniques would cost closer to $2 million.

When the expenditure is 75% less on re-fracturing, it doesn't require nearly as much of a production increase to generate acceptable economics.

Chesapeake Energy details some re-fracturing success that it has been having in the Haynesville Shale gas play in Louisiana.

Fig 5- Pre and Post Re-frack rate



Source: Chesapeake Q2 earnings.

The graph depicts a 700% improvement in Chesapeake's rate of production that shows a big increase, to be sure. The more important take away from this is that there is big potential for the industry to get a significant production and reserve bump from re-fracturing. More importantly, these production and reserve boosts can be gained profitably, perhaps more profitably than by drilling entirely new wells.

VI. Conclusion

Re-frac economics dependent on well cost versus cost and returns on an effective re-frac design. The timing of the re-fracs ranged from nine to 43 months, with a small difference between EUR increases on time tore-frac groupings of nine to 12 months (50 percent EUR increase), 13 to 23 months (68 percent EUR increase) and over 24 months (49 percent EUR increase).

Because of imbalance in oil and gas price and variances in re-frac designs and expense, payouts are not estimated. The evolution of a re-frac design into an effective and economical treatment likely will require several jobs to deliver the best output. Incorporating learnings from fracture application and well performance into successive treatments is critical. For this reason, many companies are considering re-fracturing campaigns rather than one-off re-fracs.

The number of times a well can be re-fractured is probably a dependent function of the reservoir and the effectiveness of the initial re-frac. As fracture designs generate increased contact area and increase in the effectiveness, the number of re-fracs possible on older wells (fractured with earlier technologies) may increase, but newer wells with better frac technologies may not be improved significantly. It is definitely a question for the future.

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