

HYDRAULIC FRACTURING (FRACKING)

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Here is a start on today's subject with a definition:

- Hydraulic fracturing involves the use of sand, water and chemicals injected underground at high pressure to blast open shale rock and release the trapped gas and oil inside.
- The equipment utilized in a typical fracking installation is identified in the "What is Hydraulic Fracturing?" diagram in your package:

- The well pipe extends to a depth that the drilling crew hopes will reach the shale formation containing the petroleum products. The depth ranges I have seen go from 5,000 feet to 15,000 feet below the surface.
- One oil field reference estimated that a typical fracking site installation project could be done in two to three months (site preparation, access roads, equipment rigging, utilities and so on). The actual well drilling may take only 2 to 5 days work. One crew comes in to drill the well and install the well pipe. Naturally, there has to be an oil derrick involved, and you can see a typical derrick in the second fracking diagram.

A second crew then takes over and sets up the rest of the equipment; (water and sand handling and mixing, injection pumping arrangement, etc.)

- The pumper truck does most of the work by supplying the pressure to inject the fracking mixture (90 % water, 10 % sand and additives @ 0.5 %) at high pressure into the well pipe. Sand is the key ingredient since it holds the fractured shale open while the oil and gas come out. The horizontal turn makes the pipe operate as blast water to crack the shale formation and hopefully release the gas and oil. The 90 degree turn in the pipe to achieve horizontal flow with the small holes in the horizontal pipe sections turned out to be the miracles that revolutionized this industry.
- The water supply is generally trucked to the drill site via tankers and is a big expense at most locations. Sand comes in from Wisconsin via rail or truck. Chemical additives could be in bulk tankers, steel drums or tote tanks.
- The job site picture contained in your package shows a busy equipment situation with supply trucks, blender trucks, pumper trucks a maintenance shop and associated. One of the early problems with fracking operations was their cost, 2 million dollars for a single well compared to \$ 350,000 for a traditional vertical well. Another cost factors is that

many of the shallow fracked wells play out fairly quickly.

As you might expect, all sorts of oil companies and oil hands have claimed credit for inventing, discovering or developing fracking. A Wall Street Journal source credits George P. Mitchell (a Texas A & M engineer) as the modern fracking "pioneer". Mitchell was convinced that the thousands of oil wells drilled in Texas contained more oil and gas, and he spent 17 years poking around Texas oil fields and finally hit pay dirt in 1998 with gushers of natural gas.

Pennsylvania oil companies claim they developed fracking techniques in the 1940s, but the operations did not expand until the industry responded to the various oil crises starting in the 1970s, including the middle east oil embargo threats in 1973, concerns in 1979 over possible supply instability in Iran and others countries and the 1990 invasion of Kuwait by Saddam Hussein.

Standard Oil claims it pioneered hydraulic fracturing in 1949. Since then, an estimated 2.5 million wells have been "fractured" around the world (2012) including more than a million wells in the United States. The major USA gas or oil/gas sources correspond to big shale formations in Pennsylvania, West Texas, Louisiana, Arkansas and North Dakota.

My last reference to history is Civil War veteran Col. Edward A. L. Roberts who used left over war ordnance (called the Roberts Torpedo) for injection into the drill hole for explosion purposes. Roberts got access to left over Civil War artillery shells and came up with some sort of detonator arrangement on the shells he dropped down the oil well pipe. His exploding torpedo system is covered by a U S Patent dated from 1866.

Irrespective of who should be credited with fracking's development, it has been argued that, except for the internet, the most important technological advance of the last two decades in America has been hydraulic fracturing. This drilling technique has produced so much oil and gas beneath American soil that we are well into the brink of something once thought unattainable: true energy independence, including an estimated 200 years' supply of natural gas.

When modern fracking first began, the average job required 750 gallons of water and chemicals and 400 pounds of sand. Today, because of the vast scale of hydraulic fracturing operations, smaller wells typically use 60,000 gallons of fluid and 100,000 pounds of additives to lubricate well holes and break up underground geological formations. A larger project would typically use from 1 to 3.5 million gallons of "fracking water".

Fracking's current and potential impact on America's energy situation is significant, and as you might expect, there is

considerable disagreement on whether this is or is not a long term benefit for the Country:

- Oil imports are down 25 % for the 12 months ending in March 2013. A 100 million barrels per month reduction in imports at \$ 100 per barrel is a ten billion dollars per month favorable impact on the nation's balance of trade.
- The first book I checked out from the Allen County Library for this assignment had a picture on the front that showed the earth with a pipe and faucet leaking out of the bottom with a single drop of oil left. The message we have heard for years was that petroleum resources are finite and are due to be exhausted in the foreseeable future.
- Recent Department of Energy predictions present a different picture. The U. S. is projected to be the "King of Oil Production" by 2020, surpassing both Saudi Arabia and Russia. Other data from trade industry projections are that the USA has already passed Russia in oil production, and will surpass the middle east a lot sooner than 2020.

Current USA oil production is at its highest level in more than 20 years. Please note that not all of the oil production amount increase can be directly attributable to fracking.

- Pipelines and pipe line flows are being reevaluated. Historically, crude oil imports came in to the gulf coast for processing with refined products shipped via pipeline throughout America. Now North Dakota crude oil goes to the east coast for refining or to the west coast for refining and export. There are three additional pipelines planned in Texas and Oklahoma to move oil to gulf coast refineries.

The famous Keystone XL pipeline that the President has spent time on needs to have its flow direction reevaluated. The original plan was for heavy crude from western Canada and light crude from North Dakota to go to the U S refining complex along the Gulf of Mexico replacing imports from Mexico and Venezuela. The issue that the President has raised is broader. As long as America has an ample supply of fossil fuels at a reasonable cost, solar, wind, hydropower and other renewables will take second place. That means that money spent on pipelines and rail cars may not be spent on solar panels, windmills, biomass plants and other renewables.

The oil marketers and refiners need and appreciate the additional flexibility of moving crude oil around in rail cars. It was North Dakota crude oil headed to a refinery on Canada's east coast that was involved in the July 6, 2013 accident in Quebec that destroyed part of the town and killed

47 people.

North Dakota's Bakken crude oil, which has been involved in four rail accidents, is traveling via rail to every corner of the country: west via rail into Washington State and then south via water to refineries near Los Angeles, south to Gulf Coast refineries, north into Canada, and east to refineries in New Jersey and Philadelphia.

- The domestic supply of natural gas is now at an all time high, and prices are the lowest in decades. The infrastructure that exists and is growing to support the distribution of gas supply includes 210 gas pipeline systems, 400 underground storage facilities, 49 locations as export/import sites via pipeline and 8 liquified natural gas import facilities with two export facilities under construction.
- Truck manufacturers are offering the big trucks that run on compressed natural gas. TravelCenters of America has agreed with Shell Oil to add liquified natural gas fuel lanes to 100 of its 230 U. S. truck stop filling stations. 15 % of all oil consumption in America is by 18 wheelers transporting goods nation wide.
- Ford Motor Company is taking orders for their 2014 natural gas powered F-150 pick up truck. The compressed natural gas tank goes in the truck bed under the worker's tool box. Ford estimates that the additional \$ 7,000 vehicle cost could be off set by lower fuel costs in a couple of years.

The compressed gas supply chain is projecting that natural gas when available will go for \$ 2 per gallon equivalent. The current estimate is that there are more that 100,000 compressed natural gas vehicles and under 600 stations open to the public.

- Oil companies are short on engineers. People are moving to North Dakota to find construction jobs, where the unemployment rate is 3.7 %, less than half the national average. Workers on oil rigs in North Dakota earn \$ 70,000 in five months. Supervisors are paid \$ 300,000 per year. Investors, speculators, land owners and others in North Dakota who are lucky enough to own 2 square miles of mineral rights in the Bakken shale area get \$ 1 million up front as lease revenue and \$ 500,000 per year in royalties, estimated to last two decades. The well head value rate went from 12 -1/2 % to 25 %.

Some mineral rights owners in Pennsylvania became millionaires as lease payments went from \$ 25 per acre to \$ 2,500 an acre and then to \$ 4,000 per acre.

An August 21, 2013 drilling lease purchase covering mineral rights in southeastern Ohio involved 22,500 acres for \$ 284

million dollars (average \$ 12,000 per acre).

- The American Chemistry Council has recorded 130 plastic and chemical plant expansion announcements and credits natural gas availability and low cost. The estimate includes 500,000 plus new jobs.
- The American Petroleum Institute is prodding the U S Department of Commerce to take action on permits for 19 new liquid natural gas export terminals. The job impact estimate is 450,000 new jobs by 2035.
- Oil company lobbyists are after Congress to deregulate the export of crude oil. The Congressional ban on crude oil exports dates to the 1970s'.

Fracking companies are also investing lots of funds for water. 6 million gallons of water needed for a three day large fracking job means 300 truck loads of water (100 loads per day) resulting in a big transportation and logistics mess. The Pennsylvania fracking industry has been investing in fixed pipelines bringing Ohio River water into the work locations. The newest water pipeline taking water to Ohio and West Virginia covered 80 miles and cost a billion dollars.

Here is a summary of fracking's economic benefits:

- A study from IHS Global Insight says the oil and gas fracking boom increased your and my household disposable income by \$ 1,200 in 2012 as lower energy costs flowed to consumers.
- Lower raw material costs for America's plastic and related petrochemical manufacturers. Natural gas is a key raw material ingredient in many chemical industry manufacturing operations.
- More efficient extractions. The frackers have figured out a way that they don't drill dry holes any more.
- The country's balance of trade has been improving via a reduction in oil imports.
- Fracking in America has resulted in lots of new jobs. North Dakota, Pennsylvania, New York, Texas and Louisiana are seeing additional sources and/or amounts of State revenue.

Next up are the concerns over fracking and its environmental impact:

- Critics say fracking fouls drinking water, pollutes the atmosphere with toxic methane gas and turns rural communities into ugly industrial zones.
- Environmental and regulatory agencies are concerned over an

increased possibility for contamination of surface soil and/or ground water from leaks, spills and related mishaps associated with drilling the well and extracting oil. It is hard to imagine that the well drillers could install a million new wells each year without some spill or release incident at a job site from a broken valve, a loose hose fitting or a worker kicking over a bucket of oily water. Pennsylvania and New York environmental agencies tracking well installation spill incident reports concluded that one out of 10 should be expected.

- Risks to air quality associated with leaks of natural gas during the drilling operation or natural gas flaring until storage, pipeline or other arrangements are in place to capture and convey the material.
- Lack of capabilities for recycling and cleaning up the portion of the injected water and sand/chemicals solution that is returned to the surface (estimate 10 to 40 %) after use in the blast portion. There are few commercial or industrial facilities available for the water recycling and reuse processing.
- Requirements to move more oil and natural gas via ageing pipeline systems.
- Lack of adequate and available alternate means of moving oil from the well points to refineries. Uncertainties over the option of moving large amounts of crude oil via rail.

As a result of these environmental and related concerns, state agencies have been busy with actions to ban fracking at certain locations (New York - temporary ban) or require agency permit approval for individual well situations.

The next matter is to step back and take a look at fracking's global impact.

Nuclear Energy There are 324 nuclear powered electrical generation plants world wide (US - 104). 65 more are under construction (US 1). The U S gets around 20 % of its electricity from nuclear. The world wide ratio is 15 %. If global carbon emissions had to be reduced by 15 % by 2050 through the increased use of nuclear power, 1,000 plants would need to be built at a cost of \$ 5 trillion.

One industry expert has projected that the 250 year global supply of natural gas means the beginning of the end of electricity from nuclear energy, at least here in the USA. Recent announcements to moth ball nuclear power plants in Vermont, Massachusetts, Wisconsin, California and Florida have all referenced the current and potential impact of natural gas related power plants. I have not seen an estimate of the greenhouse gas increase attributable to replacing nuclear derived energy with natural gas derived energy, but the number has to be significant.

The world's nuclear energy future is still strong in some areas. The International Atomic Energy Agency estimate is that 90 new nuclear plants will enter service by 2030. Ten new plants went on line over the past two years. China has plans for 27 new plants, and Russia has plans for 15 more plants.

Coal Fired Power Plants The average age of America's 614 coal fired power plants is 30 years. Coal's share of electrical power generation is down to 40 % from a prior 50 %. The new power plant recently built by Duke Energy near Edwardsville, Indiana was one year late and \$ 1.6 billion over budget. There is one more coal fired power plant under construction by Southern Company in Mississippi, and then the industry says that may be it for the

traditional way of burning coal to generate electricity. America has a huge supply of coal. The greenhouse gas impact of burning coal is double the impact from burning natural gas, and coal fired power plant emissions account for about one-third of all greenhouse gas emissions. The President has made it abundantly clear that he is against new coal fired power plants.

Duke Energy announced that they will close five coal burning power plants in Indiana as part of a settlement over a lawsuit by the Sierra Club and other environmental groups. Indiana currently depends on coal for 70 percent of all electricity produced in the state.

The Tennessee Valley Authority plan is to close 8 of their coal fired power plants. Many are in the very heart of Appalachia's coal mines.

Chemical Industry -- Welcome Back to the USA The natural gas companies can make more gas available than they have places to store it. They now need big chemical plants using gas as the raw material to come back to the USA.

Where will America's Natural Gas Go? The natural gas industry built 8 facilities to handle imported liquified natural gas and 1 for the export of liquified natural gas. Next they converted one location from import to export. Now there are applications in to the U S Department of Commerce to build 18 more export terminals.

Next up are complaints from the vocal faction of the environmental community:

- They are appalled over the emphasis of a 200 to 250 year supply of natural gas. The US has a tendency to take the easy way out on energy policy. If there is a 200 year supply, then we will likely burn natural gas for 200 years, irrespective of the impact on the environment.

- They are aghast over plans to build high tech export terminals so we can sell coal to China. A portion of the coal will be burned in power plants to generate electricity. China already has air quality problems in certain locations.
- They are against the XL pipeline. It represents one more time on energy policy where "that is the way we have always done it".
- They are disappointed over the oil industry practice of flaring natural gas.

Late breaking news:

- Fort Wayne is getting a compressed natural gas filling station, out by the airport. That will make 13 in Indiana.
- Nuclear energy is not dead in America. The first new power plant in 30 years has been announced by Southern Georgia Power. There will be two reactors. The cost estimate is \$ 8 billion and the time schedule for construction is 5 years.
- Houston based Rock River Resources announced plans to build a new oil refinery in the USA. A second new refinery was announced on Monday (3/1/14). No new oil refinery has been built in America in more than 35 years.
- The list of proposed new oil pipelines has been shortened. Two projects have been cancelled due to the availability of crude oil via rail.
- America's natural gas situation hit the geopolitical news this week. Every time the Ukraine talks independence from Russia, Putin threatens to shut off their gas supply. You may have seen or read the same thing as I did. The press says Putin should be punished, and brings up USA natural gas as a means. 70 % of Russia's operating cash flow is based on oil and gas exports. Now there is another country sitting on a mountain of natural gas looking to build up its export business.
- I hope I did not give the impression that energy independence was going to happen very soon. This week's "Energy and Capital Newsletter" reminds us that currently 70 % of Saudi oil exports are destined to refineries along our gulf coast. They also look to the future and note that nearly half of the oil and gas rigs operating throughout the world are found within U. S. borders.

Let's look at the pictures:

- No 2 -- The oil derrick is at the job site only until the well is drilled and the pipe installed. It is then taken down and moved to the next drill site.

- No 4 -- Note how much construction concern is reflected at the top of the well to minimize the potential for impact on the underground aquifer. Please note also that there can be 2 miles or more distance between fresh water and where the shale is being blasted.
- No 5 - Oil pipelines in Texas, all headed to Gulf Coast refineries. America's gulf coast refining complex is the largest in the world.
- No 6 - the famous Keystone XL pipeline. I am going out on a limb and predicting that the project will be approved. Note that my prediction is no better than yours. Big oil tends to get what it wants.
- No 7 - A new opportunity for lunch. Meet a friend for a coke and sandwich down town and you can go out on the sidewalk and watch the train go by. I should say trains, because there are lots of them.
- No 8 - next are the western North Dakota rail road marshalling yard. Oil cars a mile long as far as you can see. Every day a train leaves with crude oil destined for east coast refineries. Two engines are in the front pulling, two engines in the back pushing, 128 black oil cars, 60,000 barrels of crude oil, 2.5 million gallons with a potential economic value of 6 million dollars (60,000 barrels at \$ 100 per barrel). 6 million dollars of oil revenue to OPEC is 15 cents, but multiply by 365 days and you get a different perspective (2 trillion dollars).
- No 9 - a picture of the worst case oil train accident so far, 47 people dead and half of a small Canadian town was destroyed. The Association of American Railroads and the American Petroleum Institute, prodded by the U S Department of Transportation have volunteered to reduce oil train speed from 50 to 40 MPH in critical locations.

They have also announced that a structural evaluation is underway concerning ways to strength the oil cars.

- No 10 - natural gas flaring is an oil and gas industry problem. If you are drilling for oil, the gas just gets in your way and vice versa. North Dakota's Bakken Oil Field flaring lights up the night time sky compared with Minneapolis and Chicago. Next is 100 million dollars of natural gas a month burning away. There was another incident report of an off shore rig where the drilling work got away from the crew and flared 300 million dollars worth of gas before the crew could get the well under control.

- No 11 - 50 years from now we will have to visit China to see an American dinosaur, the monster coal fired power plant, the backbone of US electricity for decades. The Tennessee Valley Authority built these all over the south east. Many were in the heart of Appalachia coal mines. China says they are working on natural gas and renewables to reduce their pollution impact. Maybe they will still be buying American coal.
- No 12 - Solar energy is on the list for renewables. The new project near Las Vegas in the California desert cost 2.2 billion dollars and is already in trouble with ecology. The system works by reflecting the sun's rays to a series of towers where the energy is concentrated to heat water to steam which turns a turbine to generate electricity. The towers are hot. It turns out that nobody told the birds.
- No 13 - When we retire and move to Florida we can still be environmentally friendly by tooling around in our own compressed natural gas powdered golf cart or watching the landscape crew mow the grass using propane power.

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10	Natural Gas Flaring.
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