Shale Plays Offer Unprecedented Opportunities

Perhaps "unprecedented" is the best way to describe the successful development of shale plays in North America. On a weekly basis there are new reports on the progress in developing shale production. Current estimates are that 2014 production will have domestically produced oil at 70% - 86% of national demand. The increasing domestic natural gas production soon will allow the U.S. to export liquefied natural gas rather than import it. As with crude oil, this was unforeseen 10 years ago, when 44 liquefied natural gas import facilities were planned for the U.S.

The success story has come from the hydraulic fracturing techniques that create voids in the oil and gas rich tight shale formations. Once created, the voids are then filled with sand and other additives that provide a porous structure for product delivery to the surface. Three dimensional seismic analysis, precise horizontal drilling capability, and down-hole tool development have further enabled the rapid development of production in these formations, which lie up to 10,000 feet below the surface, as depicted in Figure 1.

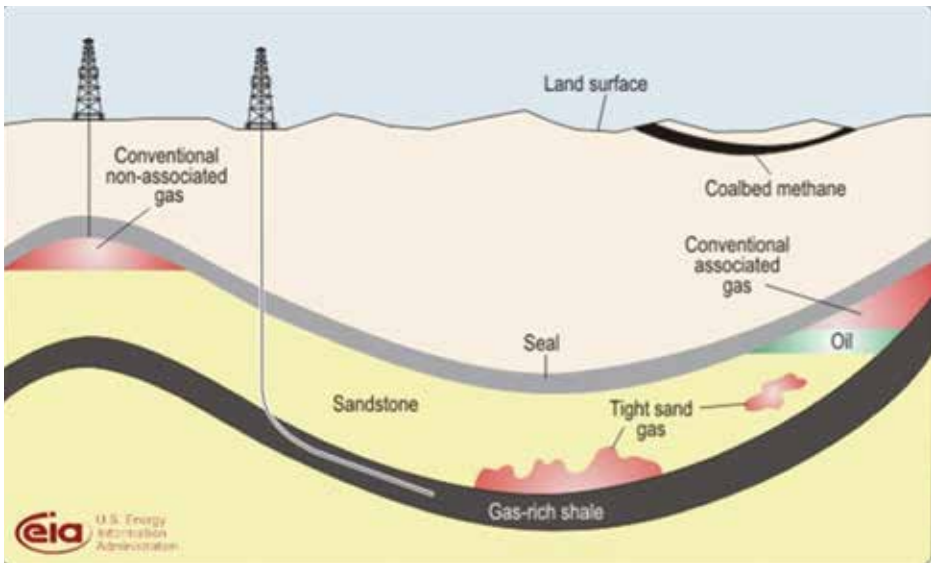

Figure 1: Geology of Natural Gas and Oil Resources [1]
(Image provided by the U.S. Energy Information Administration)

Figure 2 shows an artist's depiction of the hydraulic fracturing process having the traditional vertical well bore with fracturing, and the new horizontal drilling process that provides many more fracturing locations and voids within the shale formation.

The motivation for the recent shale play development has been high market value of oil and natural gas liquids. Development in the Bakken, Barnett, Eagle Ford, Marcellus, and Cline shale plays in the United States has begun within the portions of those plays rich with oil and natural gas liquids. Natural gas is produced as a secondary, but very abundant product. The American Gas Association has published estimates of more than a 100 year supply of natural gas for the U.S. with the addition of shale gas.

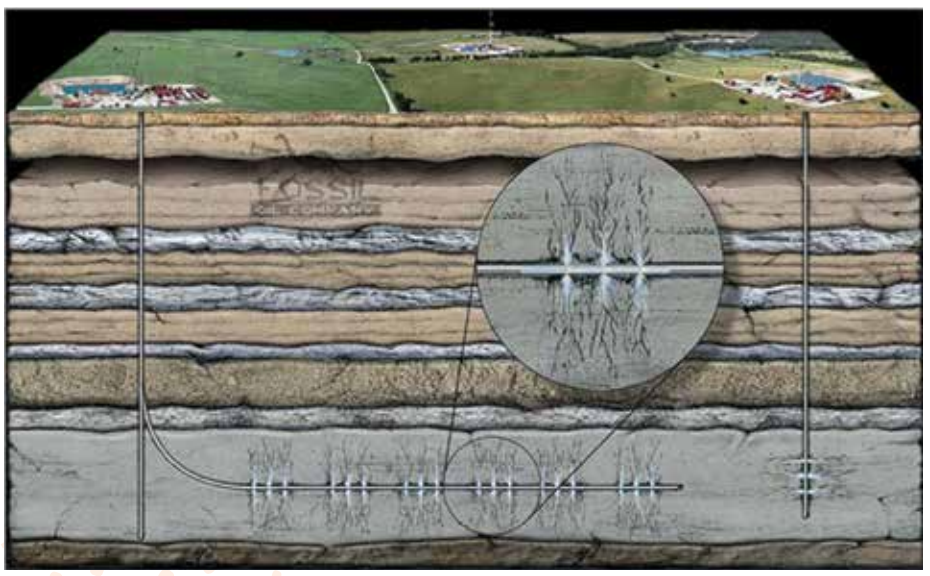

Figure 2: The Horizontal Well compared to a Vertical Well
(Image courtesy of Pennsylvania Independent Oil and Gas Association)

The good news is that the geology of the formations is layered such that many of the shale plays have other undeveloped shale formations beneath the current producing strata. This means that the shale gas and oil development can continue for decades.

The shale play "boom" has produced economic benefits in the way of jobs, services of various kinds, demand for pipe, valves, and other equipment. Demand has been increasing for gas ultrasonic meters and Coriolis meters for the liquid measurement. Control valves, flow limiters, safety equipment for over pressure protection, transmitters, process computers, and data communications equipment are also needed. Some startup companies are offering secure web hosting for operations data so that even the smallest production operator can keep close tabs on the production. Engineering firms are enjoying fully loaded schedules, skilled technicians are in high demand, and persons holding a commercial driver's license are in demand as well. On a non-technical level the local filling station, previously a cross roads quick stop that sold sandwiches and peanuts, now has a restaurant to cater to the new population of shale play workers. Thus, in the U.S., the economic benefits are available to all social sectors. Figure 3 describes the applications and end uses of natural gas liquids.

Several organisations have forecast economic growth as a result of the shale boom. According to a study published by Purdue University [2] shale oil and gas production is expected to increase the U.S. gross domestic product by an average of 3.5% annually through 2035. The study went on to declare this to be an "economic game changer for the U.S. economy." According to the American Natural Gas Alliance [3], shale development will add nearly 870,000 new jobs in 2015. The oil and gas industry is forecast to spend $48 billion in capital expenditures by 2015 [3]. Another report claims the combined impact of shale production at about one billion dollars per day [4].

The chemicals industry plans to gain from the shale developments with 97 announced investments valued at $71.7 billion [5] to expand production capacity of ethylene, ethylene derivatives, ammonia, methanol, propylene, and chlorine. By the year 2020, it is expected that 1.2 million temporary jobs and 537,000 permanent jobs will have been created [5]. Most of the increased chemical production capacity will be for export markets.

NGL Attribute Summary — eia

Natural Gas Liquid	Chemical Formula	Applications	End Use Products	Primary Sectors
Ethane	C_2H_6	Ethylene for plastics production; petrochemical feedstock	Plastic bags; plastics; anti-freeze; detergent	Industrial
Propane	C_3H_8	Residential and commercial heating; cooking fuel; petrochemical feedstock	Home heating; small stoves and barbeques; LPG	Industrial, Residential, Commercial
Butane	C_4H_{10}	Petrochemical feedstock; blending with propane or gasoline	Synthetic rubber for tires; LPG; lighter fuel	Industrial, Transportation
Isobutane	C_4H_{10}	Refinery feedstock; petrochemical feedstock	Alkylate for gasoline; aerosols; refrigerant	Industrial
Pentane	C_5H_{12}	Natural gasoline; blowing agent for polystyrene foam	Gasoline; polystyrene; solvent	Transportation
Pentanes Plus*	Mix of C_5H_{12} and heavier	Blending with vehicle fuel; exported for bitumen production in oil sands	Gasoline; ethanol blends; oil sands production	Transportation

C indicates carbon, H indicates hydrogen; Ethane contains two carbon atoms and six hydrogen atoms
*Pentanes plus is also known as "natural gasoline." Contains pentane and heavier hydrocarbons.

Figure 3: Uses of Natural Gas Liquids
Source: U.S. Energy Information Administration, Bentek Energy LLC. [1]

Twenty five applications for liquefied natural gas (LNG) export terminal construction, which require U.S. Government approval to be constructed, are in process, with one terminal already having received its government permits for LNG export beginning in 2015. Figure 3 depicts the Cheniere Energy Sabine Pass LNG export facility which will be the first LNG import terminal to be converted into an export terminal. Currently there are six other LNG import terminals in the U.S.

Construction of an LNG export terminal can cost $10 billion or more, so each is a large investment.

A major LNG terminal expansion involves the addition of several stages of gas compression, plant piping addition, perhaps the construction of more tankage with integral level and density instruments, and the construction of additional moorings and loading arms for ship loading. Shown in figure 4 [6] are six compression and liquefaction trains capable of processing up to 3 billion cubic feet of gas per day.

The decreased reliance of the U.S. on imported gas and oil is also expected to have a significant impact on future global energy markets. The full effect of this impact is difficult to estimate, but economically, it could yield more stable energy market conditions [7]. With recent events in Crimea, it is certain that there will be geopolitical effects as more U.S. LNG export terminal applications are made and encourage d to be made.

Figure 4: Cheniere Energy Sabine Pass LNG Export Terminal

The U.S. is not the only country with shale formations (see Figure 5 [1]), but it is the place with the least regulation, fewest market restrictions, and the greatest competition [7]. Competition and profit opportunity have driven the rapid development of the shale plays. It is expected that the U.S. will lead the world in shale production for some years to come.

Both on a local basis and an international basis, regulatory pressure is being placed on greenhouse gas emissions reduction [7, 8]. On September 20, 2013, the U.S. Environmental Protection Agency announced steps to reduce carbon pollution from electric power generation plants. Along with that announcement came an initiative to reduce carbon emissions from coal fired power plants and to set emission limits below currently obtainable values at existing coal fired plants [8]. Because of this, in many instances, natural gas has now become the fuel of choice with the lowest climate change impact.

Gas quality from the shale plays is variable. Produced gases from the Marcellus and Haynesville basins have resembled traditional natural gas compositions with little concern for market interchangeability with existing gas supply. Gas produced from the Eagle Ford and Bakken, however, has been enriched by flash gas recovery from condensate stock tanks, a by-product of liquid hydrocarbon production. This gas may be rich in ethane, propane, or butanes, and require processing for market interchangeability. Processing would typically be done by turbo-expander cryogenic process. Within the processing plant is the ability to remove propane and heavier components and selectively remove ethane as liquefied product.

Table 1 provides molar compositions of gas from a traditional source and the Bakken Shale formation.

Table 1: Comparison of AGA 8 Gulf Coast Gas with Bakken Production Gases [9] (Concentrations in mole %)

Component	AGA 8 Gulf Coast	Bakken A	Bakken B	Bakken C	Bakken D	Bakken E	Bakken F	Bakken G
Methane	96.52	70.23	48.07	73.93	50.79	68.05	52.9	66.17
Ethane	1.819	13.94	18.78	13.25	15.73	14.2	11.32	13.15
Propane	0.46	6.7	14.87	5.55	11.61	8.05	8.52	7.01
Butane +	0.345	5.5	16.38	4.32	14.42	6.22	6.46	9.37
$CO_2 + N_2$	0.856	3.44	1.72	2.87	7.29	3.43	19.8	4.18
Hydrogen Sulphide	0	0.19	0.18	0.08	0.16	0.05	1	0.12
Wobbe Index	1359	1470	1712	1454	1563	1491	1207	1519
CV, (Btu/scf)	1036	1281.6	1481.7	1247.6	1455.3	1306.4	1474.5	1300.6
Methane Number	98.9	53.2	43.5	56.1	44.9	51.6	49.2	48.7

Note: Calorific values have been approximated because sources did not include detailed composition

The shale gas production rate in the U.S. has exceeded the current capacity of the midstream gas processing industry. This has produced opportunities for innovative process solutions, such as portable natural gas liquid (NGL) skid-mounted units and blending arrangements with cross country transportation pipelines. In some instances, particularly in the Bakken shale play, flaring of the gas has been a solution for producers wanting to optimise oil production. Market prices drive this decision with natural gas future prices around $4.36 per million Btu and oil valued at about $99.60 per barrel.

Several refinery expansions have been made and more have been announced to handle the liquid hydrocarbon production. The export regulatory limitations that exist for crude oil and natural gas do not exist for refined product. Refiners and fractionators can maximise their profit opportunity by arranging export. This in turn offers opportunities for transportation pipeline companies to participate in the economic uplift by moving oil and natural gas liquids. As a result, some companies have converted gas pipelines to liquid hydrocarbon pipelines.

New steel mills are being positioned in close proximity to the shale developments. Orders of steel line pipe to expand the existing gathering network are expected to increase with the shale boom.

There is some skepticism internationally about how long the shale boom will last and the full economic effects, but for those regions of the U.S. participating in the shale production; it has produced economic benefits not seen since before the early 1970s. Differences are notable between states that have encouraged shale production and those that have not. In some cases, prosperity is just across the state border.

For those who are fortunate to benefit from the shale expansion, these are good times. History is replete with boom-to-bust stories in the oil and gas industry, but for now, times are good in the business. How this will ultimately play out, only time will tell.

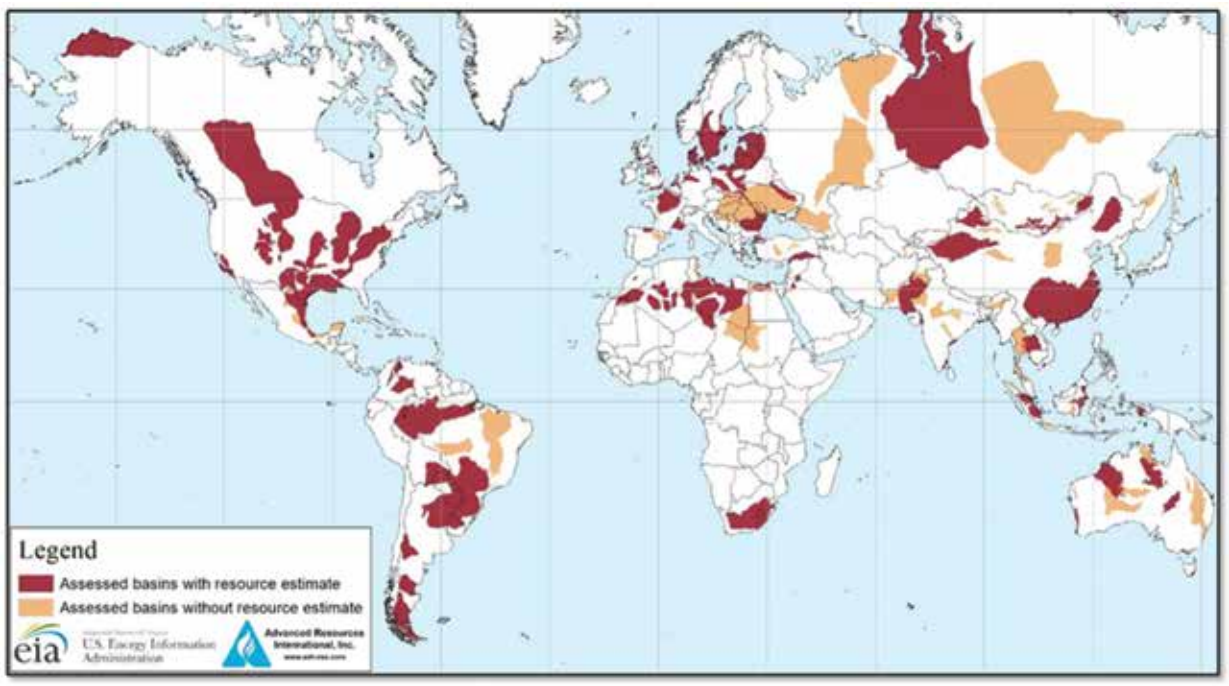

Figure 5: Map of world shale formations

References

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7) Ruhl, Christof, "The five global implications of shale oil and gas", energy post, January 10, 2014.

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About the author

James N. Witte is a staff engineer in the Fluids and Machinery Engineering Department, Mechanical Engineering Division of Southwest Research Institute. His work experience includes expertise in stewardship of company standard operating procedures and practices, gas meter and regulator station design and operation, LNG terminal material balance, applied meter station automation and remote control, natural gas metering technical training, and natural gas sampling and analysis. Since its founding in 1947, Southwest Research Institute has contributed to the advancement of science and technology by working with clients in industry and government. Performing research for the benefit of humankind is a long-held tradition. The Institute comprises 11 divisions engaged in contract research spanning a wide range of technologies. Southwest Research on the Internet: swri.org.