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Shale Gas Markets and Processes

(EPCs play a big role)

Webinar
February 7, 2018
Part 1

Introductory Note

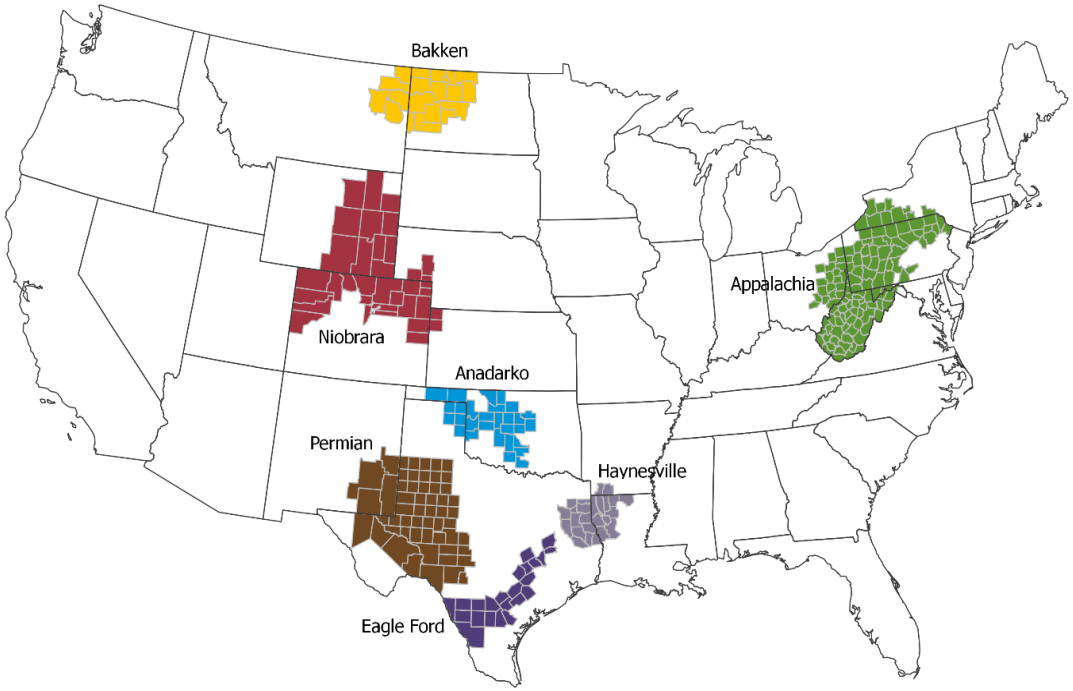
The statistics surrounding the shale gas market are changing, literally daily. Therefore, the outputs of this report should be interpreted as trend indicators, and not necessarily the final word, for example, with respect to trillion cubic feet (tcf) of gas in a particular shale play. Here are some observations that are useful for establishing the context of the report.

- Shale gas is a major worldwide opportunity, and extending from the present into the long term future of 50 to 100 years
- Shale gas is an energy "game changer" in the US, despite varying estimates regarding the total reserves
- Shale gas in Europe is not currently a game changer because of environmental, political, and geologic considerations, each of which is discussed later in this Report. The current situation will likely change.
- Shale gas in Asia is off to a slow start, despite the world's largest reserves in China, largely due to a lack of horizontal drilling and fracking equipment and know-how. China is moving to address this deficiency through investment in western companies that have the needed technologies. India is inviting outside companies to develop Indian reserves with attractive tax and duty-free policies. Australia is importing the necessary skilled labor and specialized equipment for the market.
- Shale gas in South America is off to a slow start for technological reasons as discussed above, and also because Argentina, which has the largest of the regions' reserves, has intimidated foreign investors with the recent nationalization in May 2012 of the Spanish YPF company assets in Argentina. This also will likely change. Mexico is slow to start because of political instability, drug-related violence in the shale areas, and monopoly control of energy by PEMEX.

Given almost any scenario, including the most conservative, the outlook for flow control and treatment is now positive as the oil and gas prices have risen throughout 2017. Flow control and treatment is required in record numbers to support additional pipelines, gas processing plants, LNG liquefaction plants, re-gas plants and other gas infrastructure.

Shale Oil Markets

IEA predicts that the “big 2018 supply story is unfolding fast in the Americas” and a return to the “heady days” of the first shale surge could see the US leapfrog Saudi Arabia and Russia as the world’s largest oil producer. The Permian basin is the largest growing area.



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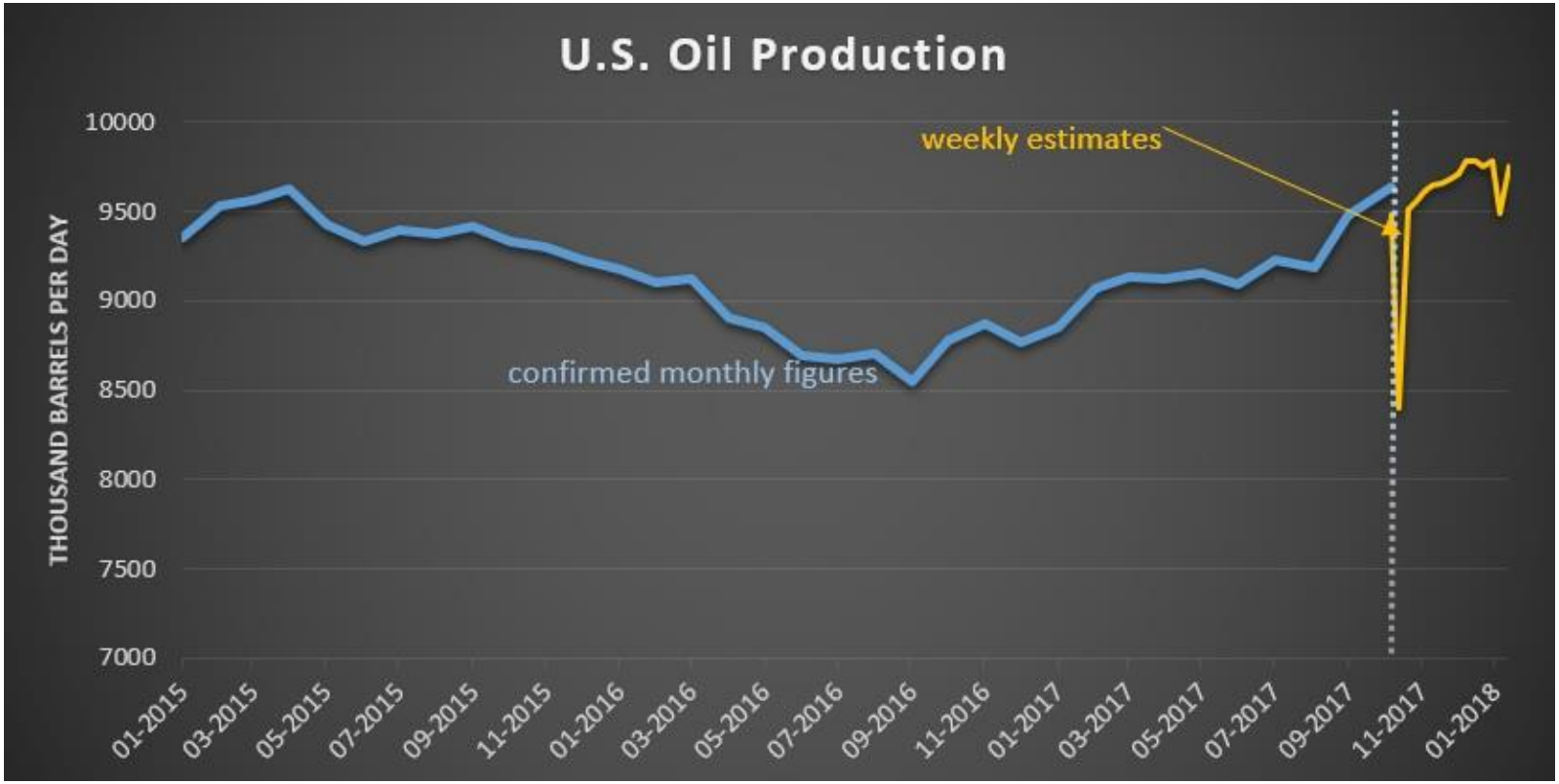

OIL AND NATURAL GAS PRICES ***(as of 01:00 PM CST 01/19/18)***

	Price	Change	%Change	Contract
WTI	63.32	-0.57	-0.89%	FEB 2018
Brent	68.68	-0.63	-0.91%	MAR 2018
Natural Gas (Nymex)	2.955	-0.033	-1.10%	MAR 2018

WEEKLY U.S. OIL PRODUCTION ***(million barrels per day)***

	Change from previous week	01/12/18	01/05/18	12/29/17	12/22/17	12/15/17	12/08/17
U.S. production	+0.258	9.750	9.492	9.782	9.754	9.789	9.780

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Oil Prices will be Subject to a Number of Factors

- The oil minister of Iran, OPEC's third-largest producer, said in January 2018 that the organization's members were not keen on increased prices as such gains would encourage more shale production.
- OPEC has no formal target for oil prices. However, Saudi Arabia, OPEC's top producer, wants to see crude above $60 to boost the valuation of its national oil company Aramco before an initial public offering of shares this year and to reduce the gap in its state budget, Saudi sources have said.
- OPEC sources say Saudi Arabia has become a strong advocate of higher prices, a shift from a more moderate stance in the past, and Saudi officials have downplayed the threat of a boost in shale production.
- Even so, U.S. production is expected soon to rise above 10 million barrels per day, close to Saudi levels, due largely to soaring output from shale drillers, government data shows. [EIA/M]
- OPEC officials also think the 2018 rally has been mainly driven by unrest in Iran, rather than a tighter balance between supply and demand, giving rise to concern it may not last. "Oil prices rose because of the political situation in Iran," an OPEC source said. "There is a worry now that this would be followed by a sharp decline in prices
- Citing third-party surveys, Schlumberger expects a 15%-20% increase in North American investments in 2018 and a 5% increase in international spending, the first growth in four years.
- Those years saw lower spending due to the slump in crude. That, plus output curbs from OPEC and its allies, has translated to a tighter market, easing the supply glut that had weighed on prices.
- "This means the oil market is now in balance and the previous oversupply discount is gradually being replaced by a market tightness premium, which makes us increasingly positive on the global outlook for our business," Schlumberger CEO Paal Kibsgaard said in a statement.

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Gas Supply and Demand

- Cold weather in the U.S. is proving to be a crucial test for the nation's natural gas market: Can record demand spurred by the cold outweigh surging production from America's shale basins, sparking a sustained rally?
- Deliveries of the heating and power-plant fuel jumped to 143 billion cubic feet on New Year's Day in the lower 48 states, PointLogic Energy data show. That tops the previous record reached four years ago during the "polar vortex," which unleashed bone-chilling conditions across the Midwest and Northeast. Gas futures have surged in response, though they're still trading at less than half the high they reached in 2014.
- America's increasing reliance on gas has stoked speculation that a frigid winter will drain the nation's stockpiles -- already below normal for the time of year -- sending prices soaring. The U.S. is exporting more gas than ever, via pipeline to Mexico and on tankers sailing across the globe, and power plants are burning record amounts as coal generators and nuclear reactors shut amid competition from cheap shale supplies.
- Though gas prices have climbed, they're far from the levels above $6 per million Btu seen in 2014. New pipelines are shuttling gas from shale plays like the Marcellus in Pennsylvania and West Virginia -- America's biggest reservoir of the fuel -- to major markets, helping to meet rising demand.
- TransCanada Corp.'s Leach Xpress pipeline, which will transport up to 1.5 billion cubic feet a day of gas from Appalachia to consumers in Ohio, West Virginia and beyond, got approval to start up . Energy Transfer Partner's Rover line, with 3.25 billion cubic feet a day of capacity from Appalachia into the Midwest and Canada, began partial service late last year and is set to be fully operational by March.
- "One saving grace is there are new pipelines out of Appalachia," with the Leach Xpress starting up at the "perfect time" to meet winter heating demand, said John Kilduff, a founding partner at Again Capital LLC in New York.

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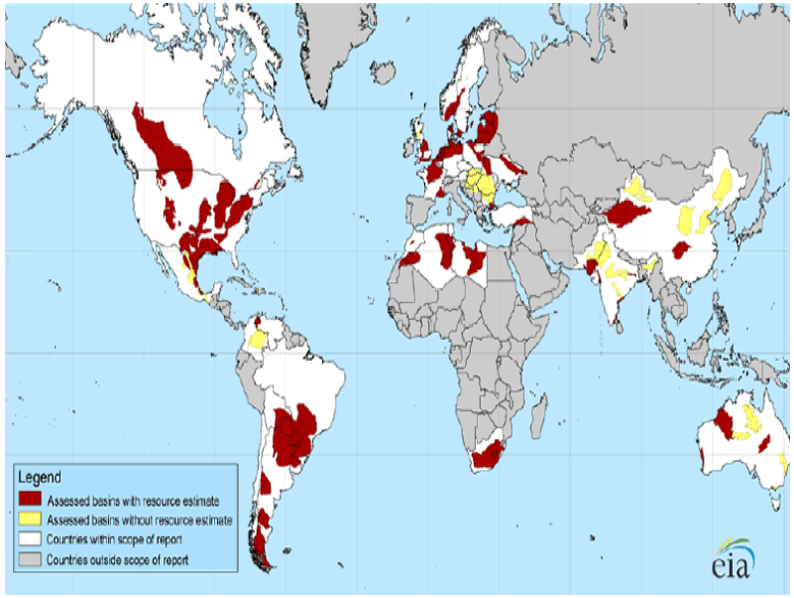
U.S. Slated to be Net Gas Exporter

- The U.S. could become a net exporter of natural gas in 2018 for the first time since 1957 due to increased sales to Mexico, the opening of new markets through liquefied natural gas and declining imports from Canada, according to the U.S. Department of Energy.
- The United States is shipping LNG to at least 20 foreign markets, the Energy Department said, and exports of LNG will continue to grow as terminals on the Gulf Coast reach capacity and companies expand or develop new terminals.
- The Houston company Cheniere has been exporting LNG since early 2016 and plans to expand its Sabine Pass complex and open a terminal in Corpus Christi by 2019. Two other Houston companies, Freeport LNG and Kinder Morgan, are scheduled to begin exporting liquefied natural gas later this year, Freeport LNG out of its Quintana Island terminal and Kinder Morgan out from its Elba Island LNG project in Georgia.
- Sempra Energy expects to start up its Cameron LNG project in Louisiana to 2019. Several companies, including Tellurian of Houston, the venture of Cheniere founder Charif Souki, have proposed Gulf Coast projects that would launch operations on the next decade.
- These projects are part of the transformation of Houston and the Gulf Coast into a global hub of energy exports, the result of booming U.S. production unleashed by the so-called shale revolution. U.S. crude exports - prohibited until late 2015, when Congress lifted a 40-year ban - have surged, hitting 1.7 million barrels a day in October, according to the Energy Department.
- Natural gas exports have helped support domestic natural gas prices, the Energy Department said. Natural gas spot prices averaged $3.01 per million British thermal units last year - about 50 cents higher than in 2016, when prices reached a near-20-year low.
- Higher prices contributed to a decline in domestic consumption of natural gas in 2017. It fell 6 percent from 2016, the Energy Department said. Higher natural gas prices meant fewer power plants switched to other fuels to generate electricity.

Shale Gas Market Overview

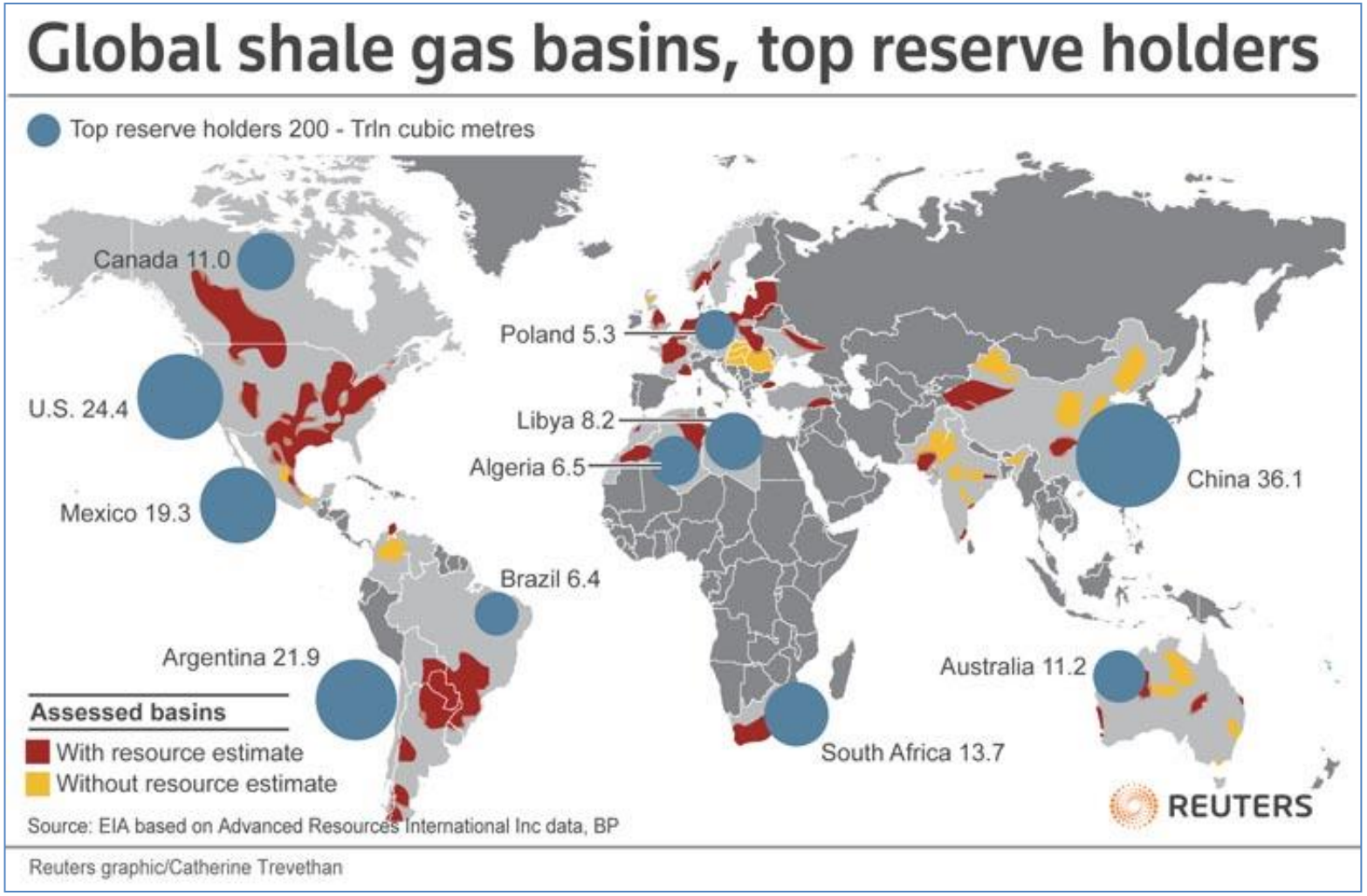
- Worldwide opportunities in “unconventional” oil & gas
  - *For oil:* ultra-deep offshore; onshore tar sand & shale for “tight oil”
  - *For gas:* onshore shale formations with horizontal drilling & fracking



North America
100 year supply: estimated but unproven
20 year supply: probable
10 year supply: proven

World
Slow start in Europe due to political issues
Slow start in China/Asia due to technology issues
Slow start in S. America due to political/technical issues

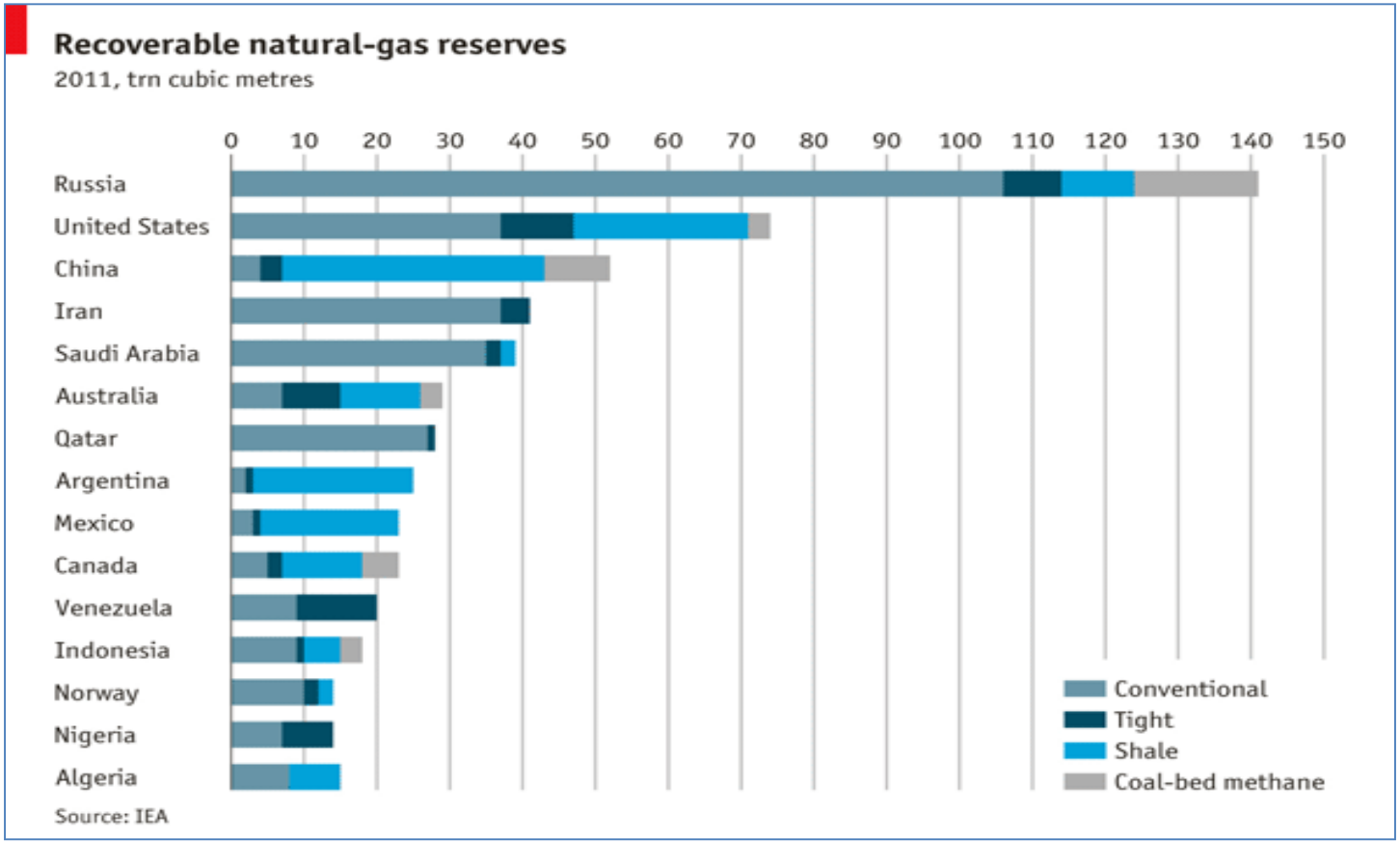
Shale Gas Market Overview



Note: 2012 EIA estimates for the US have been reduced by approx. 40% due to lower expectations for Marcellus shale. Despite that, gas development is proceeding at a rapid pace in "liquids rich" shale plays.

Shale Gas Market Overview

Conventional and unconventional gas reserves, by country



Note: 2012 EIA estimates for the US have been reduced by approx. 40% due to lower expectations for Marcellus shale. Despite that, gas development is proceeding at a rapid pace in “liquids rich” shale plays.

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Shale Gas Market Overview

- Shale gas is an energy “game changer” in US and Canada
- Shale gas in Mexico slow to develop
  - Instability in region, plus government control of all development
- In Europe, despite large reserves, shale gas off to a slow start
  - Bans on fracking; France, Germany, UK, Sweden, Bulgaria, Romania
  - In most countries, mineral rights are owned by the State, not the land owner, which slows development where national leadership has the strong support of green constituencies
  - European shale plays are deeper than the US (1.5X), and the shale strata is thin (about 50 meters vs. 90 to 180 meters in the US)
  - Some eastern European countries have 25-year gas supply agreements with Russia that make development of alternative sources problematic, even though energy independence from Russia is desired

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Shale Gas Market Asia

- In Asia, China has world's largest reserves of shale gas
- In China, despite large reserves, shale gas off to a slow start
  - China shale plays are somewhat deeper than the US and mixed with clay, and some are located in rugged areas with difficult drilling
  - Fracking and horizontal drilling equipment and know-how is lacking, which is slowing development
  - Water shortages in parts of China make extensive fracking operations more difficult to achieve
  - Despite obstacles, China will likely move ahead in near term
- In Australia, shale development starting to proceed
  - Needs additional skilled manpower, equipment and know-how
  - Will largely support LNG exports to Asia (shale gas and CBM)

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Shale Gas Market Factors

- Factors that could negatively affect future prospects
  - Drop in gas price
    - Impacting the number of gas wells, and encouraging development of “liquids rich” shale plays in western Marcellus and Bakken to provide higher margins
  - Water shortages
  - Restrictive regulations regarding fracking and produced water disposal
    - New York and Ohio, plus others have statewide or local restrictions
  - Overstatement of gas reserves
    - Reassessment of reserves in Poland has reduced initial estimate by 80%
  - Delays in development of infrastructure to support natural gas as a transportation fuel, and as a utility fuel for electric power generation
  - Warm winter weather which significantly reduces consumption and increases supply. However, 2018 is proving to be a colder than average winter

    Political barriers to shipment of LNG to other countries

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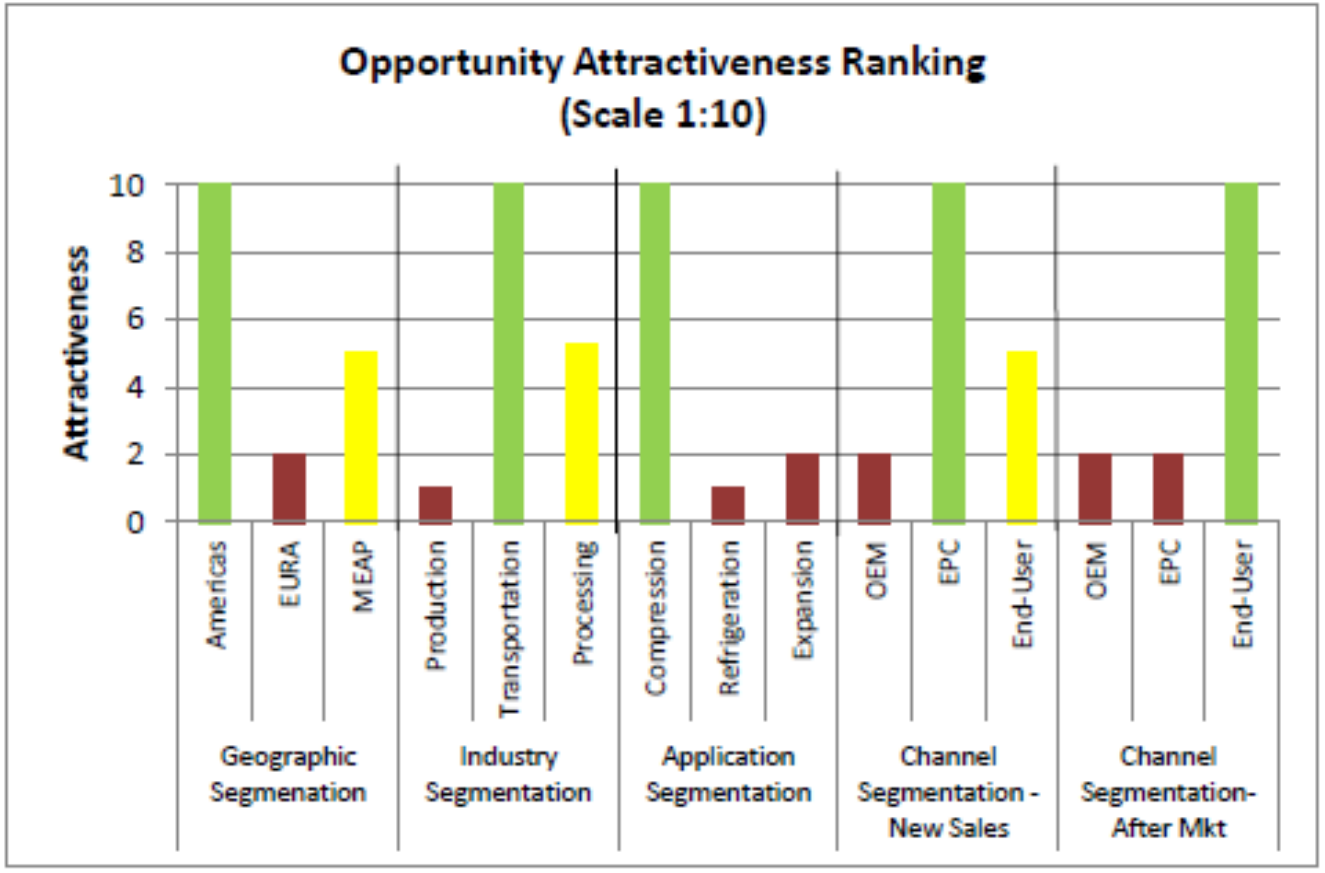
Monitor, Compressor and Valve Opportunity Ranking



The biggest pump market is in production. The biggest treatment markets are in processing. Asset management is fairly equal among segments.

Table 2. Top 10 countries with technically recoverable shale oil resources

Rank	Country	Shale oil (billion barrels)	
1	Russia	75	
2	U.S.[1]	58	(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	
	World Total	**345**	**(335)**

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

Table 3. Top 10 countries with technically recoverable shale gas resources

Rank	Country	Shale gas (trillion cubic feet)	
1	China	1,115	
2	Argentina	802	
3	Algeria	707	
4	U.S.[1]	665	(1,161)
5	Canada	573	
6	Mexico	545	
7	Australia	437	
8	South Africa	390	
9	Russia	285	
10	Brazil	245	
	World Total	**7,299**	**(7,795)**

[1] EIA estimates used for ranking order. ARI estimates in parentheses.

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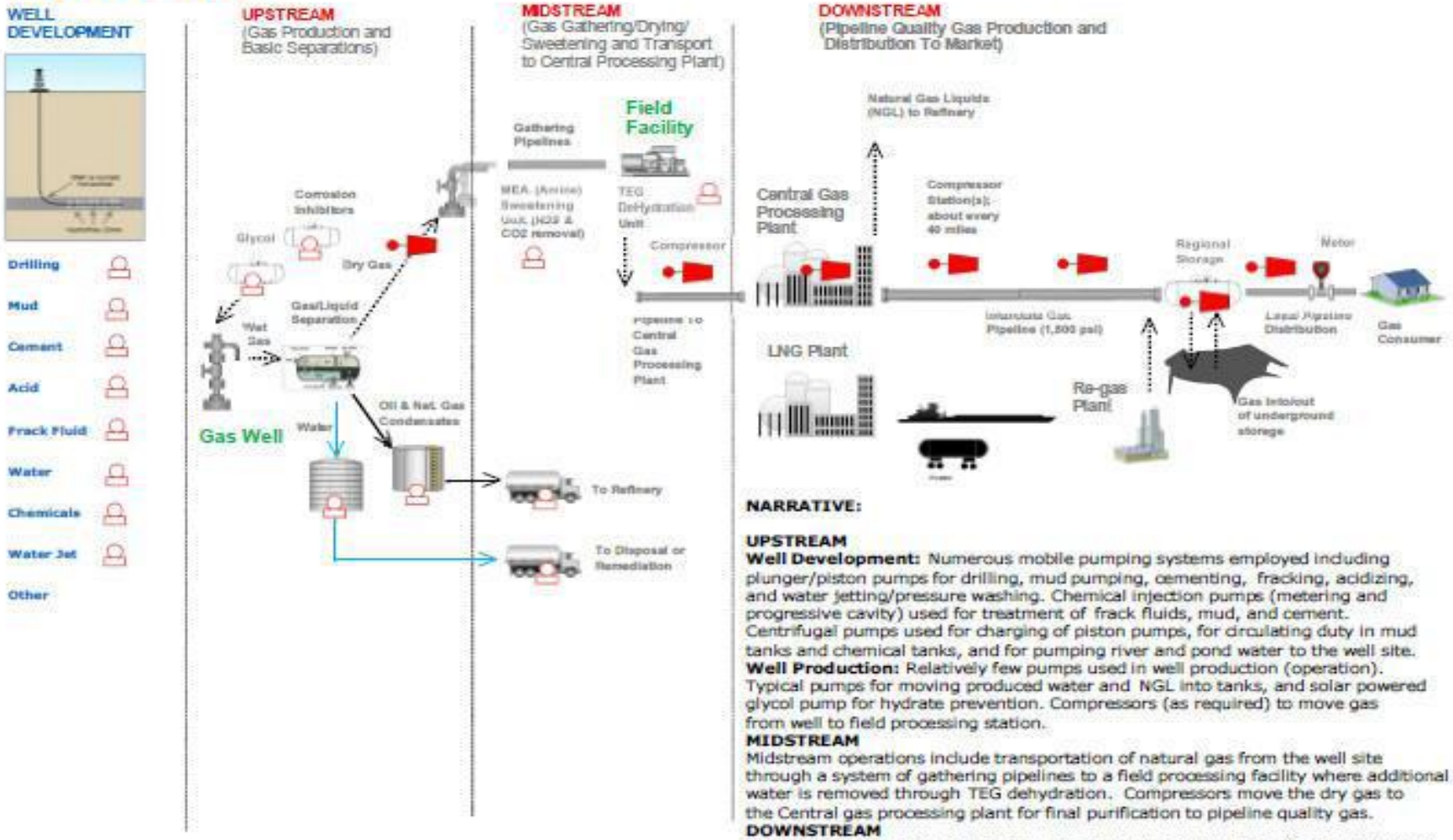
Processes

PROCESS FLOW DIAGRAM FOR ON-SHORE SHALE GAS PRODUCTION, PROCESSING & DISTRIBUTION

SHALE GAS



NARRATIVE:

UPSTREAM

Well Development: Numerous mobile pumping systems employed including plunger/piston pumps for drilling, mud pumping, cementing, fracking, acidizing, and water jetting/pressure washing. Chemical injection pumps (metering and progressive cavity) used for treatment of frack fluids, mud, and cement. Centrifugal pumps used for charging of piston pumps, for circulating duty in mud tanks and chemical tanks, and for pumping river and pond water to the well site.

Well Production: Relatively few pumps used in well production (operation). Typical pumps for moving produced water and NGL into tanks, and solar powered glycol pump for hydrate prevention. Compressors (as required) to move gas from well to field processing station.

MIDSTREAM

Midstream operations include transportation of natural gas from the well site through a system of gathering pipelines to a field processing facility where additional water is removed through TEG dehydration. Compressors move the dry gas to the Central gas processing plant for final purification to pipeline quality gas.

DOWNSTREAM

Numerous compressors required in central gas processing plant for gas drying, gas sweetening, refrigeration, and gas compression to pipeline pressure. Also, compressors are used at compressor stations along entire length of gas pipeline. In final storage, compressors are used to compress the gas for above-ground tank storage, or below ground in empty aquifers, salt domes, and other geologic structures.

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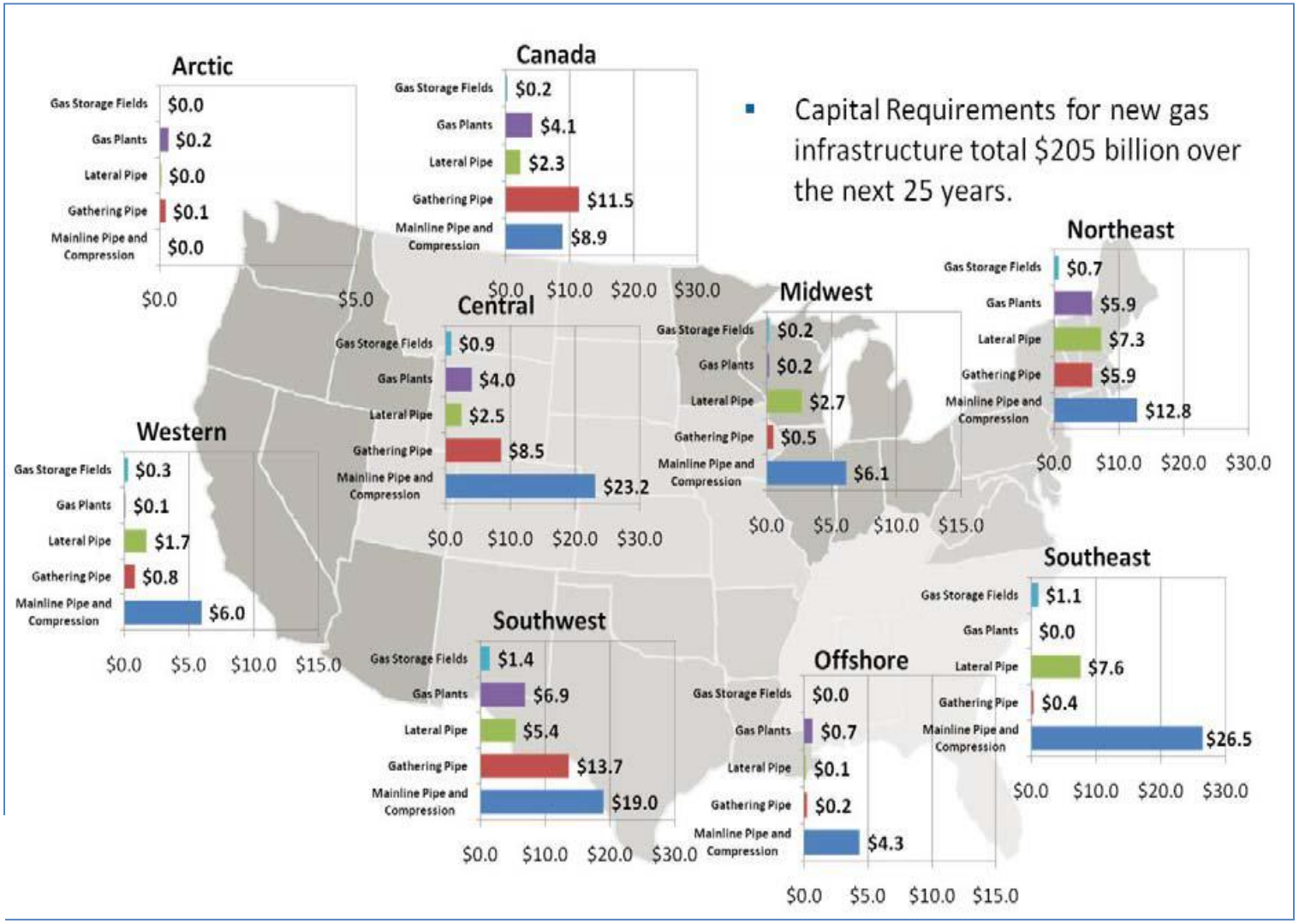
Processing Plants, Pipeline, Compressor Stations, Storage



Crude oil pipelines in the United States

Most major pipelines travel through the Midwest, Rockies and Great Plains, heading to the Gulf of Mexico. But half of U.S. consumption is on the East and West Coasts, raising transportation costs.

Source: Energy Information Administration

Other major existing oil pipelines

Chan, 23/06/2017

REUTERS

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Shell Ethane Cracker

- Shell Chemicals' $6 billion ethane cracker being built in Beaver County isn't just important to the tri-state region, it's also playing a big role in the U.S .petrochemical industry. "That essentially is the beginning of the second wave" of ethane crackers, said Todd Dina, global director of Olefins at Houston-based IHS Markit. The Potter Township plant made the list of 13 ethane crackers being built from 2017 until 2021.
- Next year there will be more tangible construction of the cracker, but Shell Appalachia is already pushing hard on the work that is happening below the surface of the site.
- “Next year we’ll start (construction of the major pieces of the plant) … and suddenly the whole skyline of the site will change dramatically,” said Todd Whittemore, global technology manager for polyethylene, Shell Global Solutions US during a session at the Shale Insight conference in downtown Pittsburgh.
- That doesn’t mean that there hasn’t been a lot of work going on at the site. There’s been the demolition of the Horsehead Holding zinc smelter, environmental remediation, a moving of a piece of a state highway, and a complete transformation of the site. And that’s not all, Shell officials said.
- “What you can’t see is all the work that is going on underground,” Whittemore said.
- That includes the construction of piping, sewers and the foundation of the buildings that will be going up starting in 2018.
- “It’s a massive amount of civil work,” Whittemore said.

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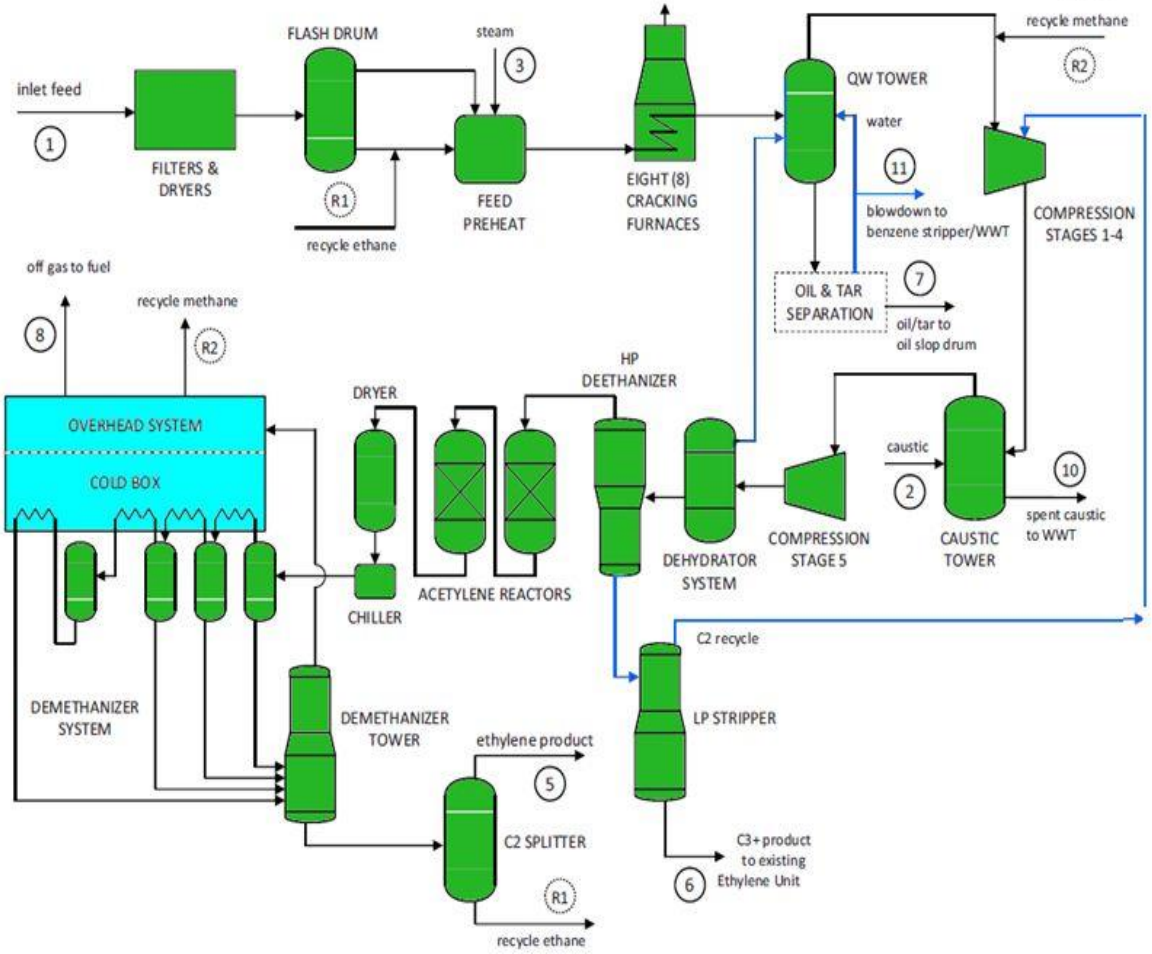
Ethane Cracker Process Flow Diagram



Chevron Phillips

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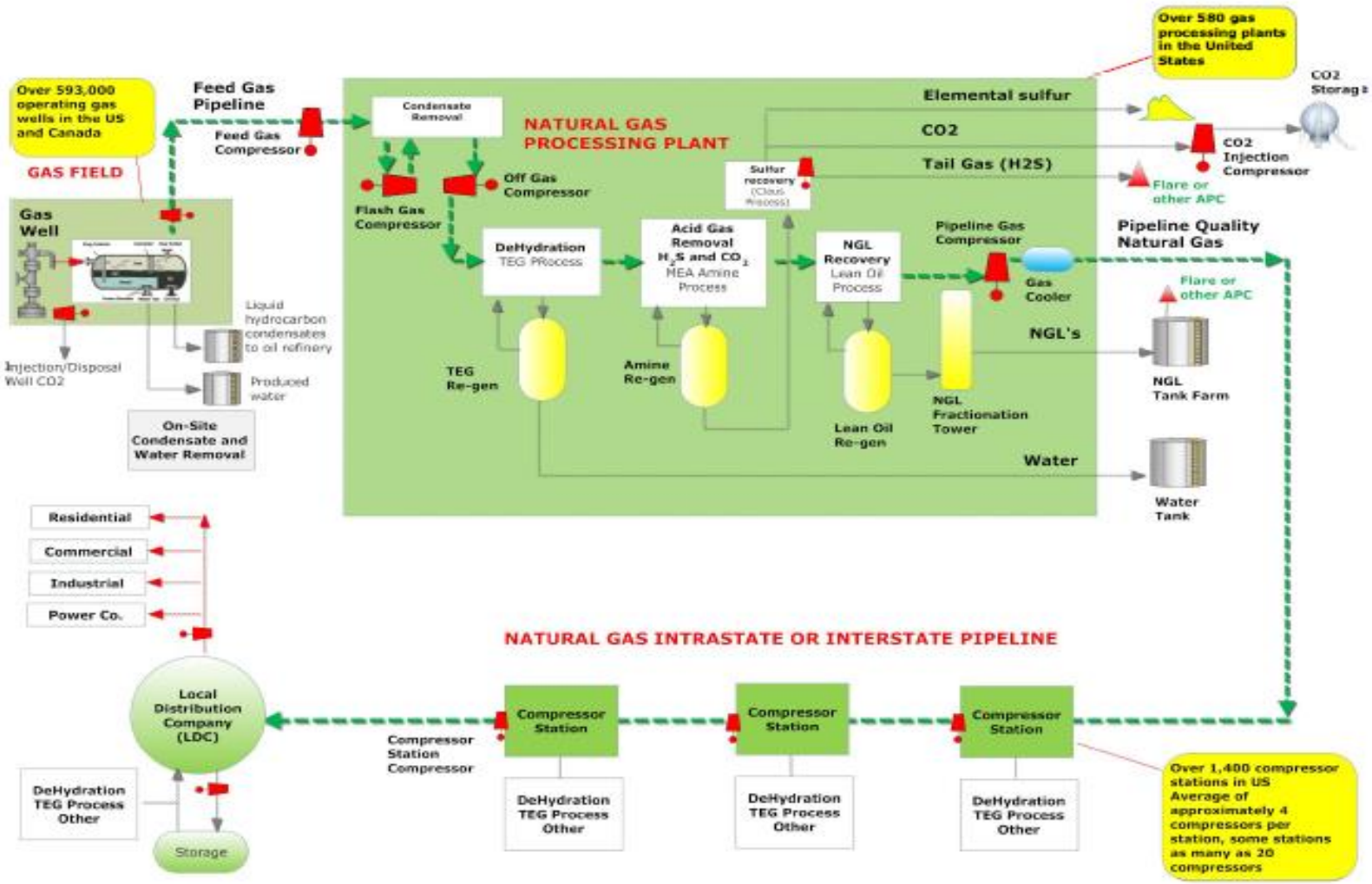
SIMPLIFIED NATURAL GAS PROCESS SCHEMATIC
WELLHEAD-TO-CUSTOMER (APPLICATIONS OF TURBO EQUIPMENT)



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Product and Application Mapping

PROCESS FLOW DIAGRAM
TANK BATTERY VAPOR RECOVERY

McIlvaine Company
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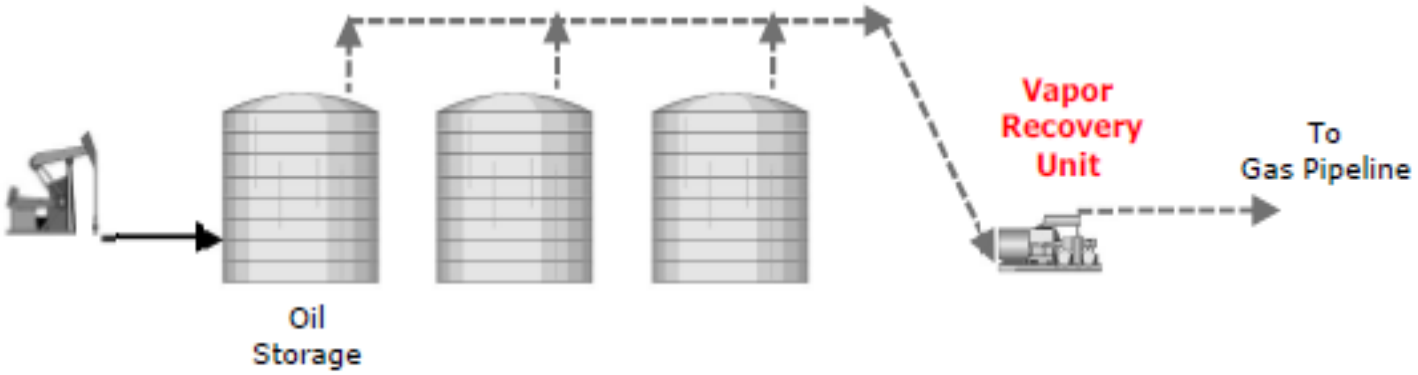

Vapors drawn off oil storage tanks at several ounces pressure and compressed to several hundred psi for injection in gas pipeline. Eliminates atmospheric venting and flaring of valuable off-gases.

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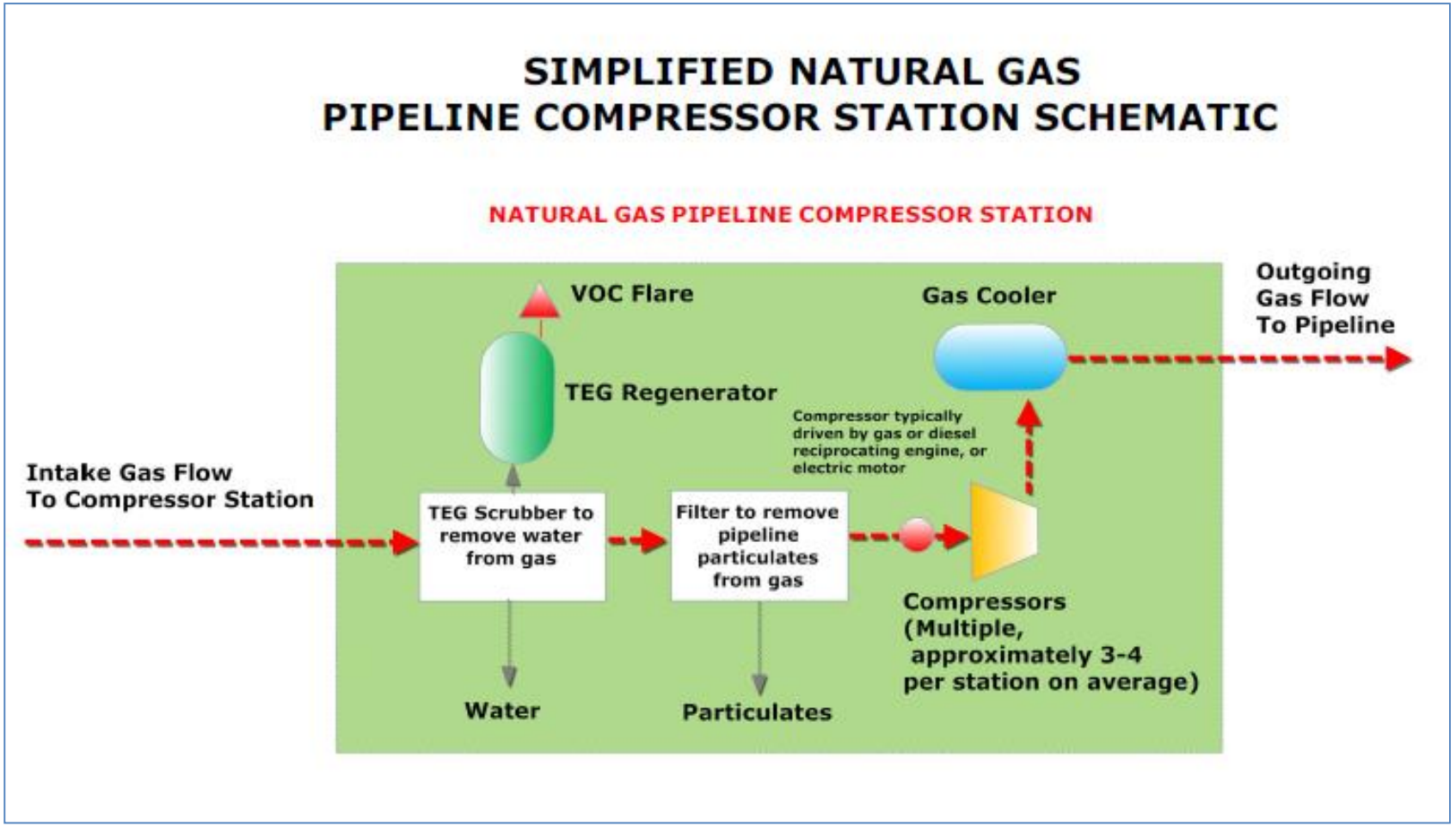
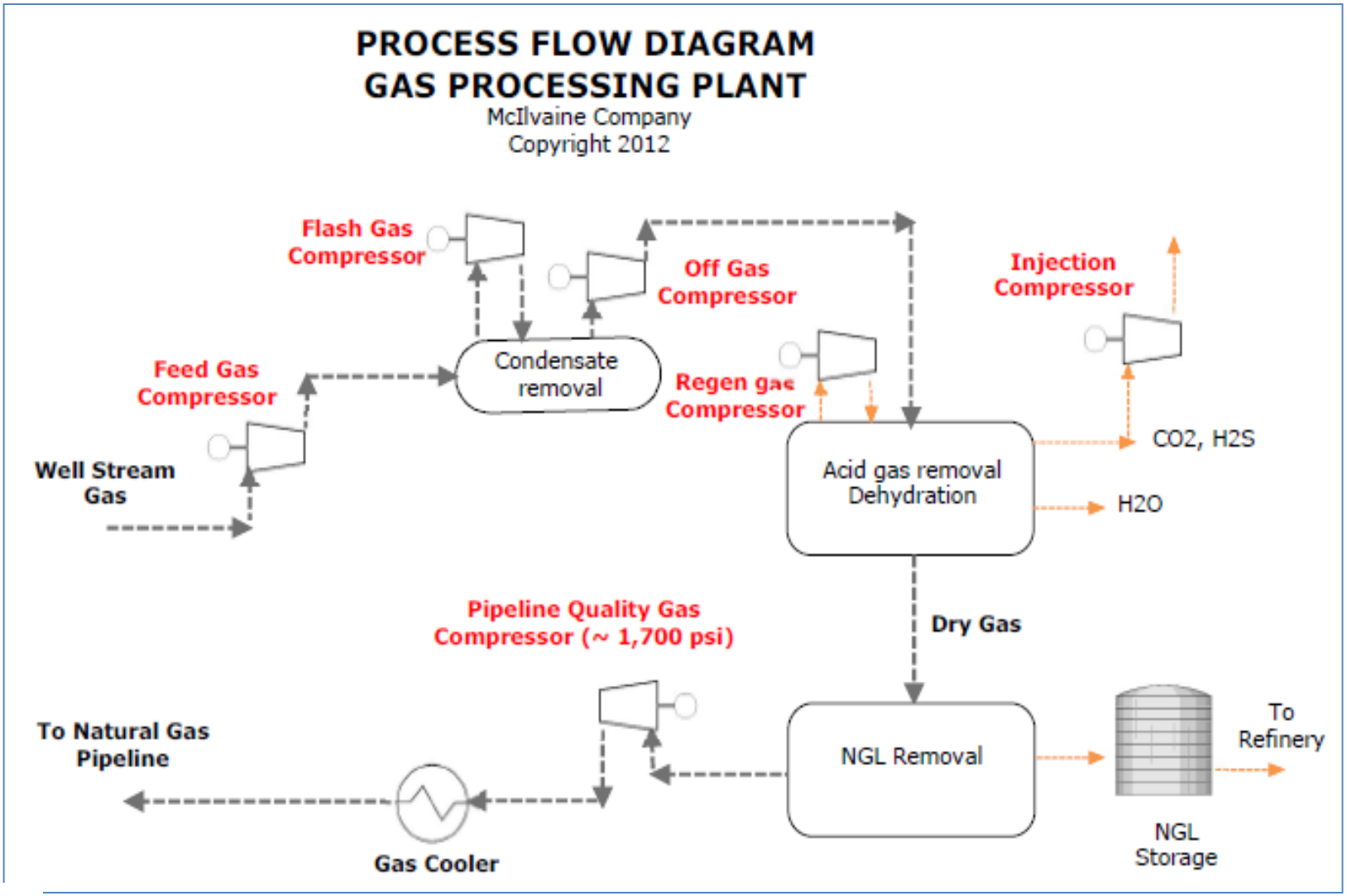
Product and Application Mapping




PROCESS FLOW DIAGRAM
GAS PROCESSING PLANT
McIlvaine Company
Copyright 2012
Flash Gas Compressor
Off Gas Compressor
Injection Compressor
Feed Gas Compressor
Condensate removal
Regen gas Compressor
Well Stream Gas
Acid gas removal Dehydration
CO2, H2S
H2O
Pipeline Quality Gas Compressor (~ 1,700 psi)
Dry Gas
To Natural Gas Pipeline
NGL Removal
To Refinery
Gas Cooler
NGL Storage

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PROCESS FLOW DIAGRAM
LNG LIQUEFACTION PLANT

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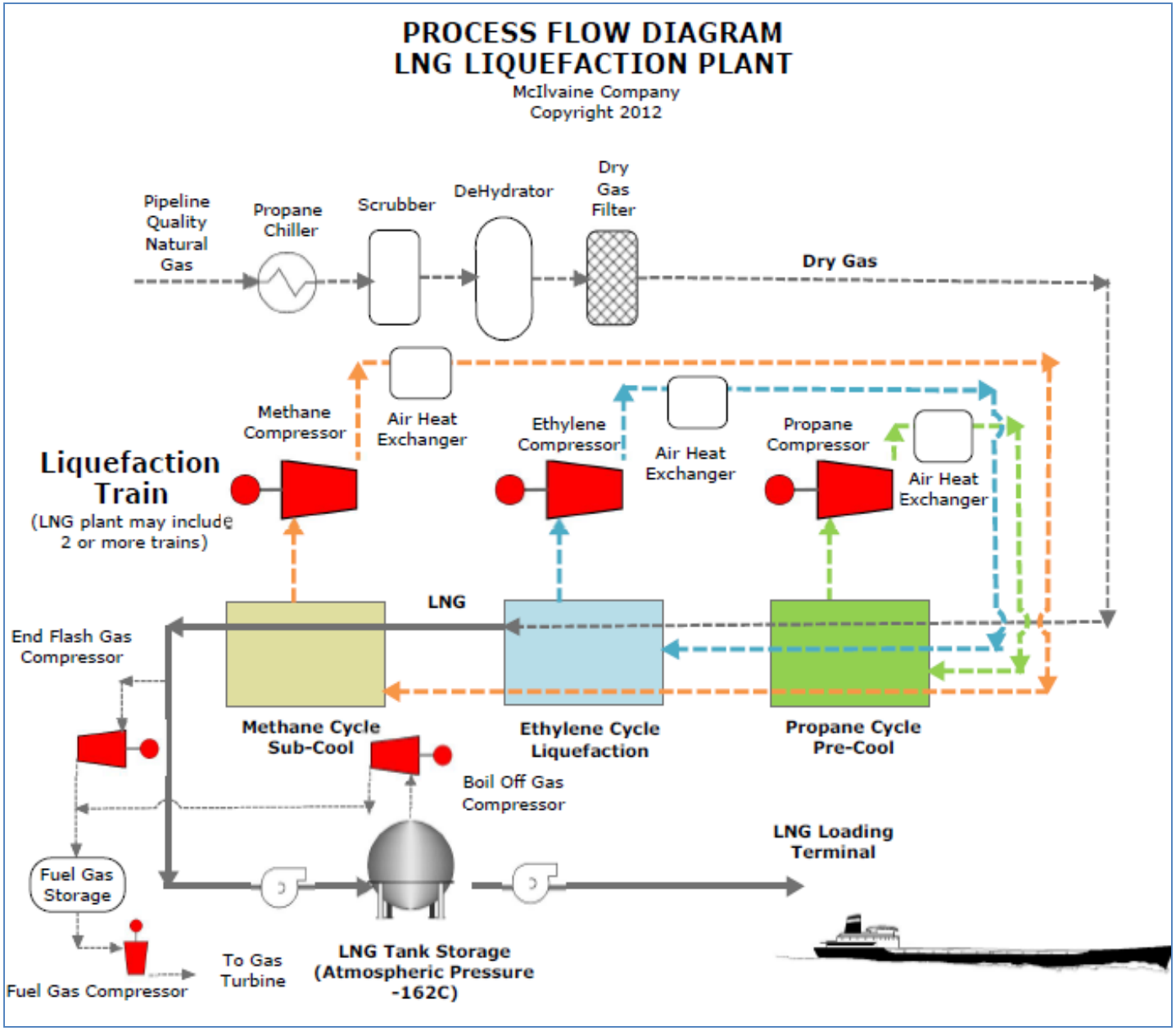

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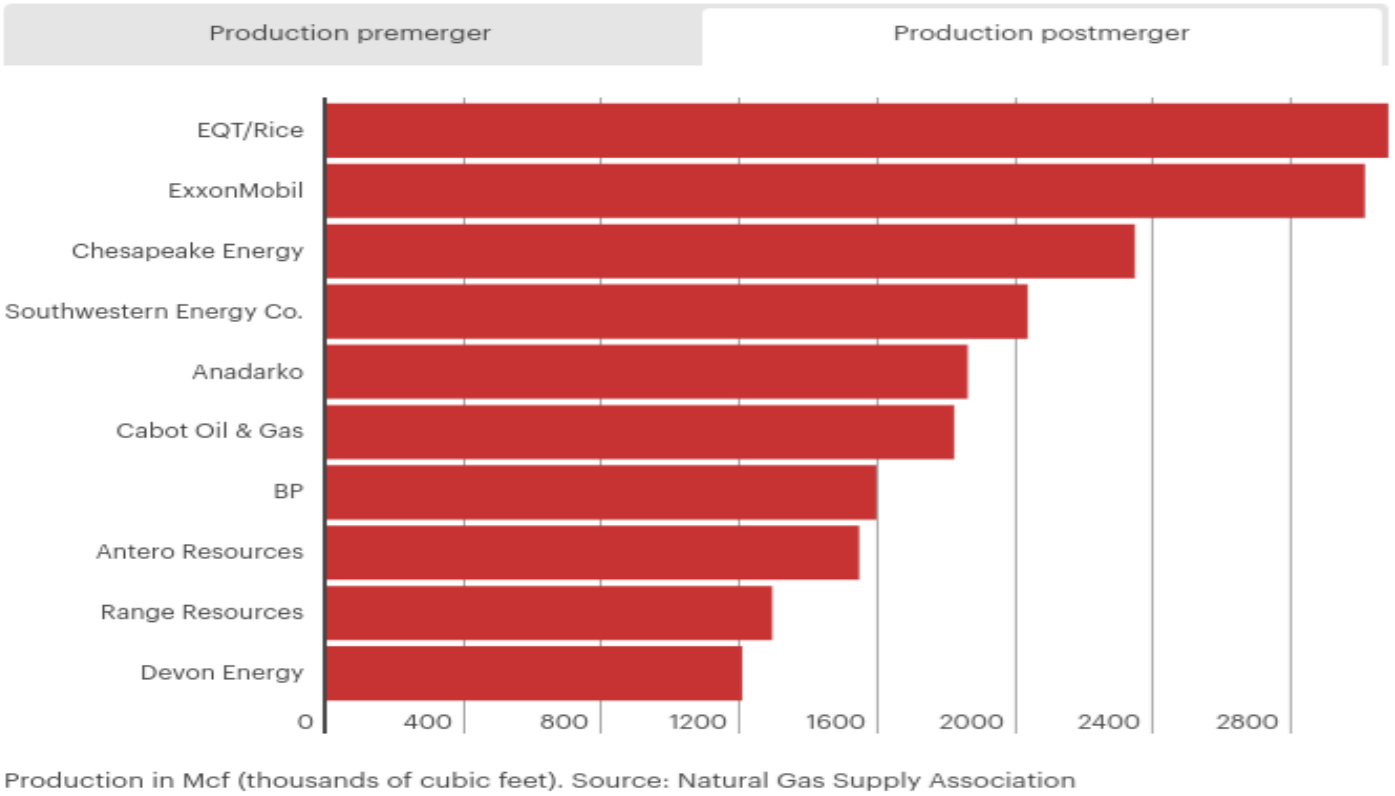
Shale Oil and Gas Producers

Profiles of each major producer along with project data are included in

N049 Oil, Gas, Shale and Refining Markets and Projects



Production in Mcf (thousands of cubic feet). Source: Natural Gas Supply Association

The top 10 producers :

1. EQT/Rice – 3,085 MMcf/d
2. ExxonMobil – 3,011 MMcf/d
3. Chesapeake Energy – 2,344 MMcf/d
4. Southwestern Energy – 2,033 MMcf/d
5. Anadarko Petroleum – 1,859 MMcf/d
6. Cabot Oil & Gas – 1,820 MMcf/d
7. BP – 1,594 MMcf/d
8. Antero Resources – 1,544 MMcf/d
9. Range Resources – 1,292 MMcf/d
10. Devon Energy – 1,205 MMcf/d

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Largest Shale-Focused Companies

EOG Resources (NYSE:EOG) has quickly become one of the nation's leading oil producers thanks to its prime positions in the Bakken, Eagle Ford, and Permian formations. In fact, according to the Railroad Commission of Texas (which, by a quirk of political history, regulates natural resources and the environment), EOG Resources was the largest oil producer in 2016, averaging 248,984 barrels of oil per day -- 9.3% of Texas' output. EOG Resources also ranked as Texas' eighth-largest gas producer, accounting for 2.8% of the gas extracted.

Shale-focused peer Pioneer Natural Resources (NYSE:PXD), ranked as Texas' second-largest oil producer in 2016, pulling 167,006 barrels per day from the Eagle Ford and Permian formations -- 6.3% of Texas' production. It was also the tenth-largest natural gas producer in the state, accounting for 2.3% of gas output.

ExxonMobil (NYSE:XOM) subsidiary XTO Energy was Texas' largest natural gas producer last year, accounting for 9.8% of production. It also ranks as the nation's largest natural gas producer, thanks to its prime position in not only Texas' shale plays but also the Marcellus and Utica formations. It's followed by **Chesapeake Energy** (NYSE:CHK), which controls significant positions in both of those gas-rich formations as well as in the Haynesville.
Turning to the Rockies,
Whiting Petroleum (NYSE:WLL) is the leading producer in the prolific Bakken shale -- a position it ascended to when it bought rival Kodiak Oil & Gas in late 2014 for $6 billion. In addition to that, Whiting is one of the leading developers in the Niobrara.

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