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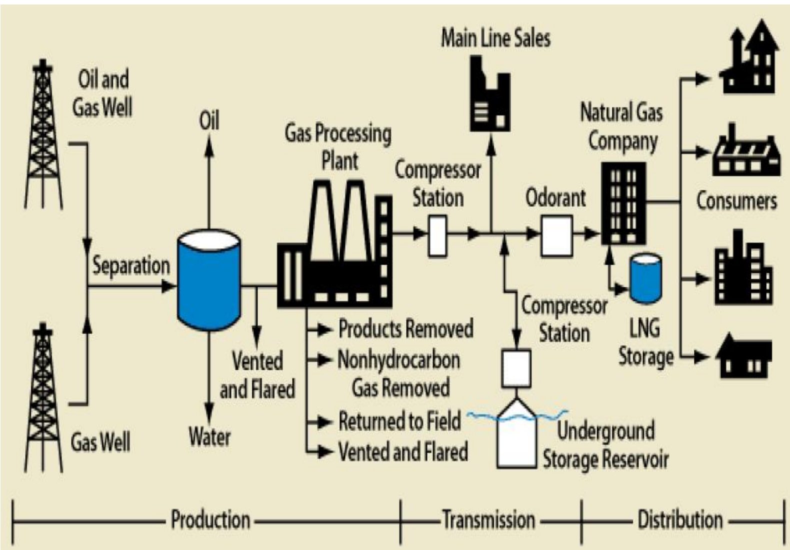

THE NATURAL GAS SUPPLY CHAIN

Exploring Redundancy, Resiliency, Capabilities and Limitations

ABSTRACT

How does Natural Gas measure up against coal, and what alternative provides greater profitability, security, and sustainability?

Brandon Palmer

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Introduction

Natural gas is a fossil fuel, (consisting primarily of methane), that is used as a source of energy for heating, cooking, and electricity generation. It is often found in coal beds, as methane clathrates, and is naturally created in a biological process by "methanogenic organisms" in environments such as bogs, land-fills and marshes.[1] As a source of dependable energy, natural gas offers unique advantages. "Gas", in its purest form, is completely colorless, shapeless, and odorless. It's highly combustible and when effectively burned, gives off a tremendous amount of energy. Unlike other fossil fuels, natural gas burns cleanly and emits impressively low levels of potentially harmful waste and byproducts into the air[2]. However, to utilize natural gas as a fuel, it must undergo extensive processing to remove nearly all elements of its make-up, beside methane. Subsequently, the refined natural gas must then be transmitted through a network of pipelines and delivered to its end point for use. In this paper I will investigate the durability, resiliency and redundancy as related to the supply of natural gas; evaluate the current infrastructure of the natural gas supply chain and its impact on meeting demand; report current market percentages of natural gas vs coal; and perform a cost analysis of natural gas vs coal from both the producer side and consumer perspective. With natural gas being one of the cleanest, safest, and most useful of all energy sources available on Earth; our ability to more effectively refine and utilize it will help us ensure longer life and greater value coming from our current actively tapped fields of already "over-tasked" oil wells[3].

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[1] *What Exactly "IS" Natural Gas?*, Editorial Dept of Oil Price.com - Sep 28, 2009. https://oilprice.com/Energy/Natural-Gas/What-Exactly-IS-Natural-Gas.html
[2] Ibid.
[3] Ibid.

Durability, Resiliency and Redundancy of Natural Gas Supply

The natural gas market and available supply are vast. According to The World Bank, about 141 billion cubic meters (bcm) of natural gas was flared worldwide in 2017; which is a slight reduction from the 148 bcm flared in 2016.[4] Russia continues to be the world's largest gas flaring country. In the United States, natural gas vented and flared increased by 12.5% in 2017 totaling 235,570 million cubic feet[5]. To put this in perspective; in 2017 alone, the United States had over 33.35 trillion cubic feet (Tcf) in natural gas gross withdrawals, 27.29 Tcf in dry gas production, 27.11 Tcf in natural gas consumption and over 125 billion cubic feet in net exports. With such a high rate of consumption, one would logically question how long we can sustain this consumption based on known supply? As of January 1, 2016, there were about 2,462 Tcf of technically recoverable resources of dry natural gas in the United States[6]. Of note, technically recoverable reserves include both proved reserves and unproved resources. Nonetheless, the US Energy Information Administration estimates that if consumption remained at the 2016 rate of about 27.5 Tcf per year, (which was higher than the 2017 rate of 27.11 Tcf), the United States has enough natural gas to last about 90 years. In comparison, proven coal and oil reserves are equivalent to around 150 and 53 years at current production levels[7]. The largest "end uses" of natural gas in the United States are Electric Power Generation, Industrial and Residential; which account for 34%, 29% and 16% of consumption respectively.

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[4] *New Satellite Data Reveals Progress: Global Gas Flaring Declined in 2017*, The World Bank July 17, 2018. https://www.worldbank.org/en/news/press-release/2018/07/17/new-satellite-data-reveals-progress-global-gas-flaring-declined-in-2017

[5] U.S. Energy Information Agency, *Natural Gas*. https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcf_a.htm

[6] *How much natural gas does the United States have, and how long will it last?*, U.S. Energy Information Agency. https://www.eia.gov/tools/faqs/faq.php?id=58&t=8

[7] *Where is coal found?*, World Coal Association. https://www.worldcoal.org/coal/where-coal-found

Acknowledging that there is ample supply, we must now look at the sequence of processes involved in the production and distribution of natural gas and evaluate its durability, resiliency, and redundancy in providing uninterrupted supply to both vital national infrastructure and residents throughout the United States. Threats to the natural gas supply chain can be a natural or man-made occurrence; it can be an individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, and/or property[8]. If an adversary (or nature) could somehow disrupt the United States supply of natural gas, thus impeding our ability to generate electricity, provide heating and cook meals; not only would this severely impact our quality of life, but this could potentially render vital infrastructure exposed and provide a temporary competitive advantage to the adversary. As such, the ability of the natural gas supply chain to withstand wear, pressure, or damage is critical. It is the industry's position that incidents, whether anthropogenic or natural, should be managed by local and state governments, under the construct of the National Response Framework (NRF)[9].

Resiliency in the natural gas supply chain speaks to its ability to resist, absorb, recover from, or successfully adapt to adversity or a change in conditions. A resilient system is one that can recover quickly from difficulties and limit impact to operations. One-way resiliency is built into operations is to identify critical components and choke points and incorporate redundancy. Redundancy, in the engineering sense, is the inclusion of extra components that are not strictly necessary to functioning but are intended to increase the reliability of the system; typically, as a backup or fail-safe. Redundancy within the US natural gas supply chain enables critical components to continue to operate in case of disruptions to the system. Recognizing the critical components, and their placement within the system, provides the context to understand the consequences, both upstream and downstream, of an impacted

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[8] Energy API, *Understanding our Natural Gas Supply Chain*. https://www.api.org/~/media/Files/Policy/Safety/API-Natural-Gas-Supply-Chain.pdf

[9] Oil and Natural Gas Industry Preparedness Handbook, American Petroleum Institute, April 2016.

component in the natural gas supply chain. For example, processing plants, pipelines, market hubs and storage facilities are all critical components in the production and distribution of natural gas. The US natural gas supply chain has over 500 natural gas processing plants, over 305,000 miles of natural gas pipeline, over 30 major market hubs and over 400 storage facilities.[10] The cross-connect capabilities of these critical components enable uninterrupted supply in the event a facility or region is disrupted. In addition to redundancy, resiliency is also achieved by the methodology, policy and procedures employed to make the system tolerant to stressors. In this regard, resiliency is deeply embedded in the design of the US natural gas supply chain which incorporates rapid response capabilities with automatic response triggers. Altogether, the redundancy of components and the resiliency of the system design prevent traditional chokepoints in the natural gas supply chain[11].

Current Infrastructure and Capabilities

The US natural gas supply chain consist of upstream, midstream, and downstream functions. Upstream includes drilling and production; midstream includes treatment and transportation; downstream includes industrial, residential and commercial uses. With a focus on accessing durability, resiliency and redundancy, I will take an in depth look at the processing, transportation, storage, and distribution capabilities of the US natural gas supply chain. Specifically, I will access the current capabilities of processing plants, pipelines, storage facilities and hubs; all of which are critical chokepoints whose operations are vital to uninterrupted supply and distribution.

[10] Energy API, *Understanding our Natural Gas Supply Chain*. https://www.api.org/~/media/Files/Policy/Safety/API-Natural-Gas-Supply-Chain.pdf
[11] Ibid.

Processing Plants

With over 500 natural gas processing plants, the United States accounts for 20% of the world's total natural gas production. Natural gas processing begins at the well head and the objective is to produce 'pipeline quality' dry natural gas, (also known as methane), that can be used as fuel by residential, commercial, and industrial consumers. To accomplish this, processing plants purify raw natural gas by removing common contaminants such as water, carbon dioxide (CO2) and hydrogen sulfide (H2S). Since raw natural gas comes from a variety of sources: oil wells, gas wells and condensate wells; its composition varies and depends on the type, depth, location and the geology of the area.[12] In 2017, the US produced an average of 71.1 billion cubic feet per day (Bcf/d) and became a net gas exporter for the first time in 60 years.[13] Texas, Pennsylvania, and Oklahoma are the top three natural gas producing states accounting for 23%, 20% and 9% of national production respectively.

The United States now has a nearly 100-year supply of clean-burning natural gas that we didn't know about just a few years ago. With a dispersed and capable processing plant infrastructure, the United Stated natural gas processing capabilities are durable, resilient and redundant. US production capacity is forecasted to grow faster than demand which indicate the US should be a net exporter of natural gas for the foreseeable future.

Pipelines

The US natural gas pipeline network is a highly integrated transmission and distribution grid that can transport natural gas to and from nearly any location in the contiguous United States. Pipelines can

[12] *Processing Natural Gas*, NationalGas.org, SEP 2013. http://naturalgas.org/naturalgas/processing-ng/
[13] Naureen Malik. *U.S. Becomes a Net Gas Exporter for the First Time in 60 Years*, Bloomberg Jan 2018. https://www.bloomberg.com/news/articles/2018-01-10/u-s-became-a-net-gas-exporter-for-the-first-time-in-60-years

be characterized as interstate or intrastate. Interstate pipelines are long-distance, high-capacity pipelines that transport natural gas throughout the nation; Intrastate pipelines link natural gas producers to local markets and the interstate pipeline system. There are three major types of pipeline systems that bring natural gas from the point of production to the point of use: Gathering Pipelines, Transmission Pipelines, and Distribution Pipelines. Gathering pipeline systems gather raw natural gas from production wells and transport it to large cross-country transmission pipelines. Transmission pipelines are the prime mover of the network as they transport natural gas thousands of miles from processing facilities throughout the United States. To put this in perspective, there is currently over 305,000 miles of natural gas interstate transmission pipeline in the United States. These pipelines have more than 11,000 delivery points, 5,000 receipt points and 1,400 interconnection points that transfer natural gas throughout the country; as well as 24 hubs that offer additional interconnections.[14] Distribution pipelines can be found in thousands of communities from coast to coast and distributes natural gas to homes and businesses through large distribution service lines.[15]

The US natural gas pipeline infrastructure is extremely critical as over 95% of natural gas used in the United States moves from well to market entirely via pipeline. As such, the Federal Energy Regulatory Commission (FERC) defines the rate-setting methods for interstate pipeline companies, as well as determines rules of business. Furthermore, the governmental agency is solely responsible for authorizing the construction and operations of interstate pipelines, storage fields and LNG facilities.[16] While this paper is specifically addressing infrastructure vulnerabilities, I will mention that shared data networks of pipeline operators have experienced cyber attacks this year. These attacks highlight a

[14] *How Do US Natural Gas Pipelines Move Gas to Markets?*, Rigzone. https://www.rigzone.com/training/insight.asp?insight_id=334
[15] *Natural Gas Pipelines*, Pipeline 101. http://www.pipeline101.com/why-do-we-need-pipelines/natural-gas-pipelines
[16] Ibid, 14.

potential vulnerability that will be addressed in a separate paper. Additionally, natural gas distribution pipelines are responsible for the majority of serious gas pipeline safety incidents. These incidents tend to occur in densely populated areas. Excavation damage is the leading cause of serious incidents along natural gas pipelines; although, significant and preventable contributors also include equipment failure, incorrect operation, and pipeline corrosion. However, as it pertains to infrastructure, the US natural gas pipeline system is durable, resilient and redundant. The robust cross-connect capabilities, coupled with the diversification of delivery and receipt points, allow the system to recover quickly from difficulties and limit impact to operations.

Storage

Natural gas storage is used to balance seasonal fluctuations in production and consumption. About 20 percent of all natural gas consumed each winter comes from underground storage. Natural gas is stored in three principal types of large underground storage systems: depleted natural gas reservoirs, aquifers, and salt caverns. More than 80% of natural gas storage capability consists of depleted reservoirs, which are relatively easy to convert to storage facilities after use and are typically located near consumption centers and existing pipeline systems. All storage fields in the US report their total working gas capacity, total field capacity, and maximum daily deliverability. The United States has over 400 active underground storage facilities and below is an EIA breakdown from July 2016:

Table 1: US Lower 48 Storage Characteristics

	Number of Fields by Type	Working Gas Capacity (Bcf)	% of Total Working Gas Capacity	Total Field Capacity (Bcf)	% of Total Field Capacity	Maximum Daily Deliverability (Bcf/d)	% of Total Maximum Daily Deliver-ability [5]
Aquifer	46	452	9%	1445	16%	9.7	8%
Depleted Field	333	3845	80%	7086	77%	75.5	64%
Salt Dome	39	489	10%	703	8%	33.1	28%
Total	**418**	**4786**	**100%**	**9233**	**100%**	**118.3**	**100%**

Source: EIA, ABB Velocity Suite, ICF

Working natural gas is defined as the amount of natural gas stored underground that can be withdrawn for use. According to the US Energy Information Agency, as of November 30th, 2018, there were 2,991 Bcf of working gas in storage. This number is down 19% from last year; however, increases in US domestic production of natural gas and the buildout of infrastructure to deliver it to consumers may have reduced the need for operators to store as much natural gas.[17] Natural gas can also be stored as liquefied natural gas (LNG), which reduces its volume to 1/600th of the volume of natural gas; making it more efficient and practical to store and transport. 55% of US working gas storage capacity is owned and operated by interstate and intrastate pipeline companies; 26% by local distribution companies, investor owned utilities or municipalities; and the remaining capacity is owned by independent storage operators.[18] As mentioned previously, 2017 was the first time in 60 years that the US was a net exporter of natural gas. As production continues to outpace domestic consumption, net exports are forecasted to continue at an increasing rate. The EIA is predicting a 16% increase in natural gas exports from 2017 to 2018.

Storage is also used to keep natural gas flowing to customers in the event of temporary disruptions in production and helps interstate pipeline companies balance system supply on their long-haul transmission lines. The flexibility and resiliency provided by storage is critical to maintaining reliable and responsive natural gas delivery. Additionally, the geographical dispersion of storage fields adds durability and decreases the susceptibility of attack. I have included in the appendix a map showing the locations of US underground natural gas storage facilities and a breakdown that shows the Midwest region (Illinois, Indiana, Michigan, Kentucky) currently has the largest working gas inventory; followed closely by the South Central region (Texas, Oklahoma, Kansas, Louisiana).

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[17] U.S. Energy Information Agency. *Natural gas storage likely to enter winter at lowest levels since 2005*, OCTOBER 12, 2018.
[18] Hua Fang, Anthony Ciatto, Frank Brock. *U.S. Natural Gas Storage Capacity and Utilization Outlook*, July 19, 2016.

Hub

Natural Gas Hubs are physical transfer points where several pipelines are connected. I have included hubs in this analysis because hubs are a key feature of competitive gas markets as hubs are where natural gas is priced and traded throughout the country. There are over 30 major 'market hubs' in the United States including the world's biggest natural gas hub: the Henry Hub in Erath, Louisiana. Gas delivered at Henry Hub is the basis of most U.S. natural gas futures; which is by far the world's biggest gas derivatives market and used to price U.S. LNG exports. The settlement prices at Henry Hub are used as benchmarks for the entire North American natural gas market and parts of the global LNG market. The Henry Hub benefits from vast domestic production and consumption in the United States, as well as the world's biggest and most freely accessible pipeline network, which stretches into Canada and Mexico[19]; offering natural gas shippers and marketers' ready access to pipelines serving markets in the Midwest, Northeast, Southeast and Gulf Coast regions of the U.S. In 2017, the United States had more than 29 Tcf of marketed natural gas production.

With ample natural gas supply, a robust, resilient and redundant infrastructure, and a well-developed commodity trading apparatus, the U.S. is poised to remain a world leader in the natural gas and LNG markets. The United State has been the world's top producer of natural gas since 2009. As natural gas usage increases worldwide, it is the infrastructure (processing plants, pipelines, storage, and hubs) that will continue to provide the United States its biggest competitive advantage.

[19] Reuters. *Q&A: What is a gas trading hub, and how are they established?*, December 29, 2017.

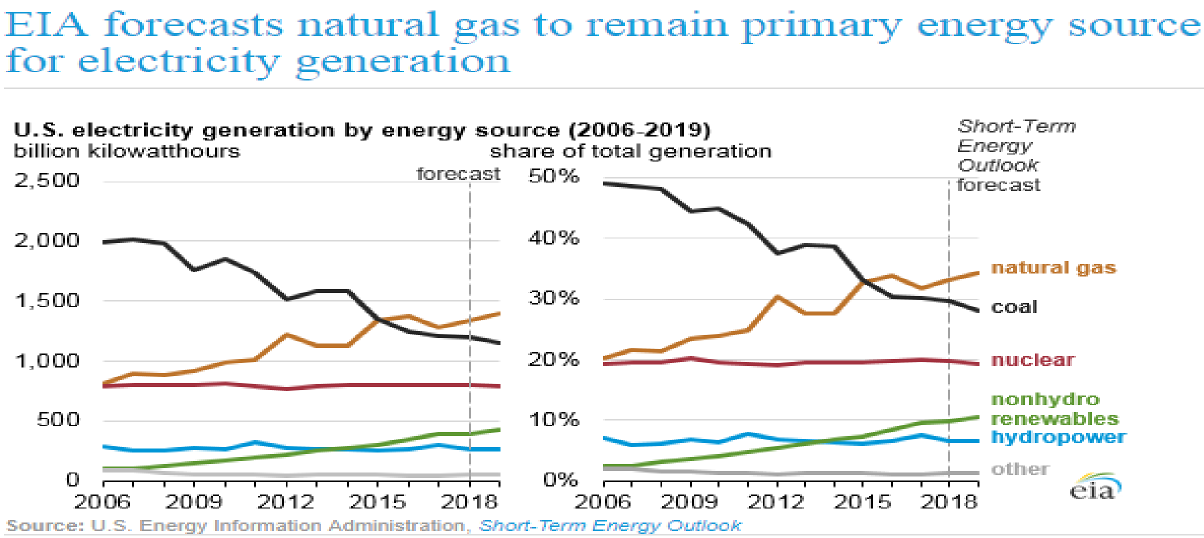
Current Energy Production and Consumption

The United States owes much of its economic prosperity in the era of electricity to inexpensive coal power. Since power plants began electrifying the U.S. in 1882, coal was unchallenged as America's least expensive power source. As the lifeblood of our economy and society, energy prices have a tremendous affect on quality of life. When energy prices rise, the costs of goods and services throughout the economy rise, stifling economic growth and household living standards. When energy prices fall, the costs of goods and services fall, stimulating economic growth and benefiting household living standards.[20] Therefore, without affordable coal power, American living standards would not have been as high as they have been the past century.

However, recent technological advances have made the recovery of America's huge natural gas reserves efficient and inexpensive. As such, natural gas has been a disrupter in the energy production market can continues to eat at the market share of coal. Since 2008, coal-fired generation has dropped 25 percent in the U.S., and in 2016, gas surpassed coal as the top electrical power source in the U.S. (33% natural gas verse 32% coal). The economic impact of natural gas overtaking coal is that American electricity became less expensive. American electricity prices are now lower in inflation-adjusted dollars than they were in 2008.[21] A reduction in energy cost provides American consumers more money to spend on goods and services. The U.S. EIA chart below shows the declining usage of coal; the rise of natural gas; the overtaking of coal by natural gas in 2016; and a short-term forecast where the margin between natural gas and coal is expected to increase over the next few years.

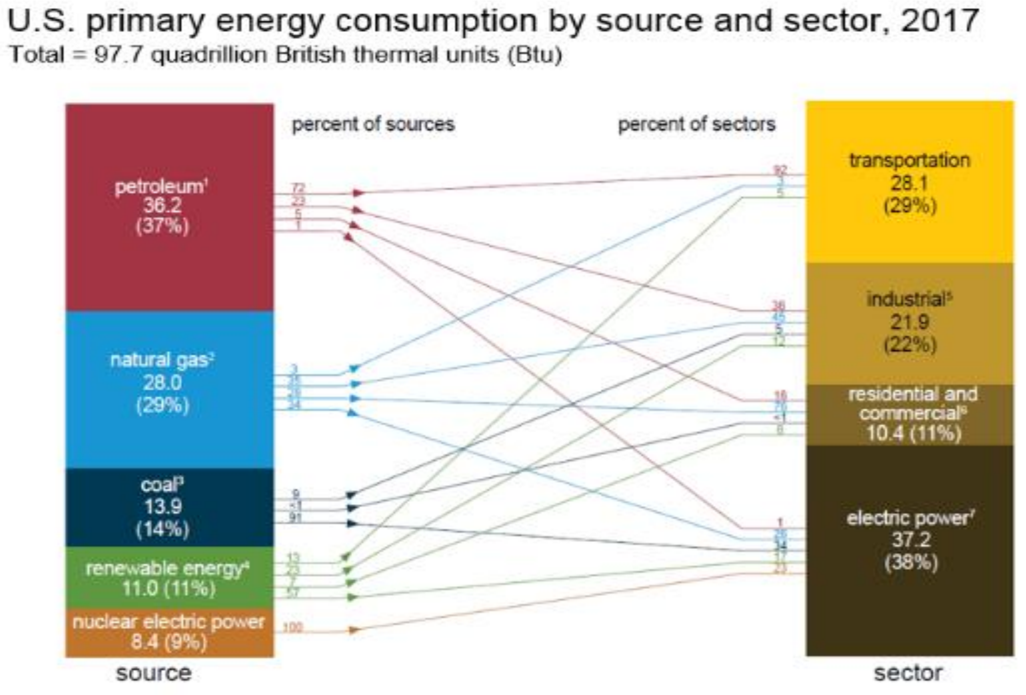
[20] James Taylor. *Closing Coal Power Plants, Replacing With Natural Gas, Makes Economic Sense*. Forbes, February 26, 2018

[21] Ibid



There are five primary energy consuming sectors in the United States. Their shares of total energy consumption in 2017 were: Electric power, 38.1%; Transportation, 28.8%; Industrial, 22.4%; Residential, 6.2%; and Commercial, 4.5%.[22] The three major fossil fuels, (petroleum, natural gas, and coal), combined for 77 percent of U.S. primary energy production in 2017; with natural gas leading the way with 32%. Although natural gas produced the most energy in the U.S. throughout 2017, the dominance of petroleum in the transportation sector resulted in petroleum having the highest primary energy consumption; accounting for 36% of all energy consumed. Natural gas finished second in consumption with 28%; followed by coal at 14%. The chart below illustrates U.S. energy consumption by sector. I wish to highlight that natural gas was the dominant source in the residential and industrial sectors accounting for 76% and 45% of consumptions respectively.

[22] U.S. Energy Information Agency. *U.S. Energy Facts Explained*. May 16, 2018.



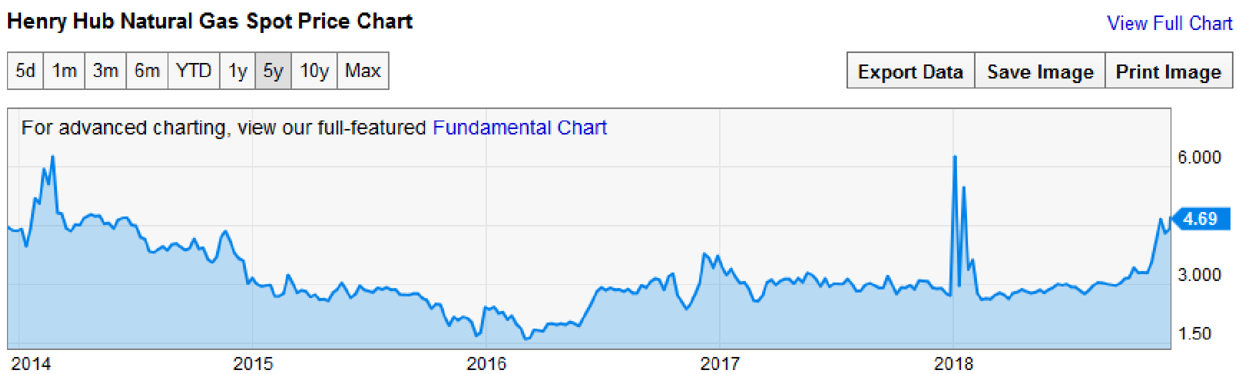
Natural gas consumption fell by 1.4% in 2017; which is a change from recent trends. Unlike coal consumption, which has decreased in 8 of the past 10 years, natural gas consumption has increased in 8 of the past 10 years. These trends resulted in natural gas consumption being twice the consumption of coal in 2017. The growth in natural gas consumption is driven largely by the increased usage in the electric power sector. Overall, U.S. consumption of natural gas increased by 24% from 2005 to 2017.[23]

Cost Analysis - Natural Gas vs Coal

Currently, natural gas generates the largest share of electricity in the U.S. and its hold on the marketplace is set to tighten. The U.S. Energy Information Agency expects nearly 32 gigawatts (GW) of new electric generating capacity will come online in the United States in 2018; more than any year over

[23] Independent Statistics and Analysis, US Energy Information Administration, July 2018, https://www.eia.gov/todayinenergy/detail.php?id=36612

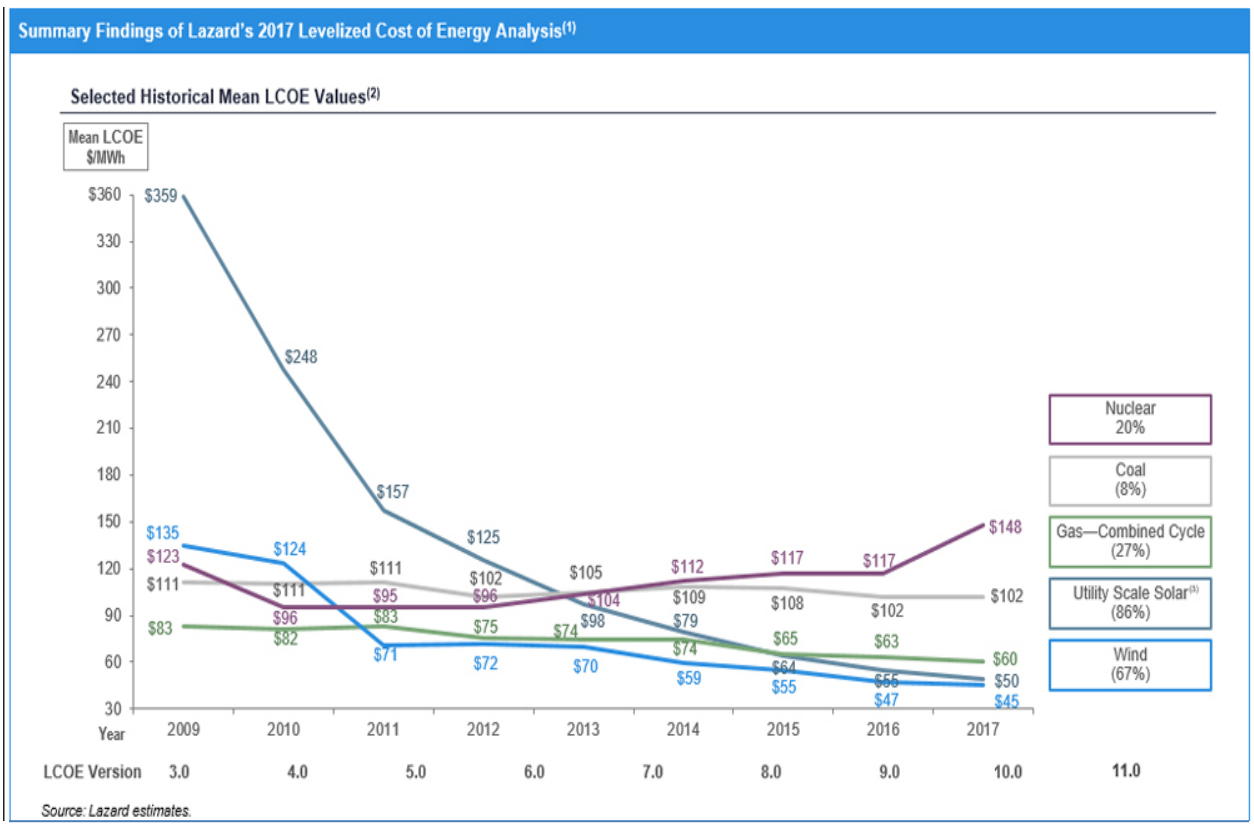
the past decade.[24] Of that 32 gigawatts, 21 GW will come from natural gas-fired generators. In contrast, 27 coal plant closures were announced in 2017, totaling 22 GW of capacity. Despite the growing demand for natural gas, (from the power sector, manufactures and exports), natural gas prices are falling. Natural gas delivered to generators averaged $5 per million Btu in 2014; $3.23 per million Btu in 2015; and $2.78 per million Btu for most of 2016.[25] The below chart shows that natural gas spot prices have remained low, and as of December 14th, 2018, a Henry Hub natural gas futures contract for delivery in April 2019 was priced at $2.878 per million Btu.[26]



Natural gas consumption is highly seasonal, and prices tend to correlate with storage levels. As noted previously, United Stated working natural gas storage was reported at 2,991 Bcf as of November 2018. This is the lowest level of natural gas entering winter since 2005. Increased demand, coupled with low inventory levels, have elevated the supply risk and caused a temporary spike in the natural gas spot price. For example, the Henry Hub natural gas spot price December 5th, 2018 was $4.69 per million Btu, whereas the spot price throughout the majority of 2018 was below $3.00 per million Btu. A similar spike occurred in late 2017 and prices returned to normal after the peak season.

[24] U.S. Energy Information Agency. *Natural gas and renewables make up most of 2018 electric capacity additions.* May 7, 2018
[25] Mark Perry. *The Real Cause of Coal's Collapse*. U.S. News, March 9, 2017.
[26] CME Group. Natural Gas (Henry Hub) Last-day Financial Options Quotes for Apr 2019.

Because the distinct ways of generating electricity incur significantly different cost, the levelized cost of energy (LCOE) is used to compare different methods of electricity generation on a consistent basis. The LCOE is an economic assessment of the average total cost to build and operate a power-generating asset over its lifetime divided by the total energy output of the asset over that lifetime. The LCOE is also considered the average minimum price at which electricity must be sold in order to break-even over the lifetime of the project. Based on Lazard's 2017 Levelized Cost of Energy Analysis, the mean LCOE for natural gas is $60 per MWh; whereas the mean LCOE for coal $102 per MWh.[27] This implies that natural gas can be sold as much as 58% cheaper than coal.



[27] *Lazard's Levelized Cost of Energy Analysis,* Version 11. November 2, 2017. https://www.lazard.com/perspective/levelized-cost-of-energy-2017/

The emergency of natural gas has certainly been a game changer in the energy market. In addition to its cost benefit, natural gas is also more efficient at producing electricity than coal. The percentage of energy input retained when converting coal to electricity is 29%; in comparison, natural gas retains 38% of its energy when converted to electricity. All indications are that market forces prefer natural gas over coal. U.S. coal consumption is projected to decline nearly 4% in 2018 to its lowest level since 1979. Despite the Trump administrations attempts to rescue the coal industry, the economics do not appear to be favorable. James Van Nostrand, director of the Center for Energy and Sustainable Development at West Virginia University College of Law, said “Coal jobs aren’t coming back, due to market forces, not due to regulation. Natural gas is cheaper and more plentiful.”[28]

Conclusion

This paper took an in depth look at the United States natural gas supply chain infrastructure and assessed its ability to meet the energy needs of the country. I specifically looked at chokepoints and potential bottlenecks to see how susceptible the supply chain is to attack or other threats that could interrupt the supply of natural gas to end users. It is important to note that threats to the natural gas supply chain can be a natural or man-made occurrence. However, a resilient supply chain has the ability to resist, absorb, recover from, or successfully adapt to adversity or a change in conditions. My research has shown that the U.S. natural gas infrastructure is expansive, hard for other countries to imitate, and built with durability, resiliency and redundancy embedded in its architecture.

A brief financial analysis concluded that natural gas is cheaper and more efficient at producing electric power than coal. As advances in technology expand the use of natural gas, the United States stands to benefit from its position as the world leader in natural gas production. In 2017, the U.S.

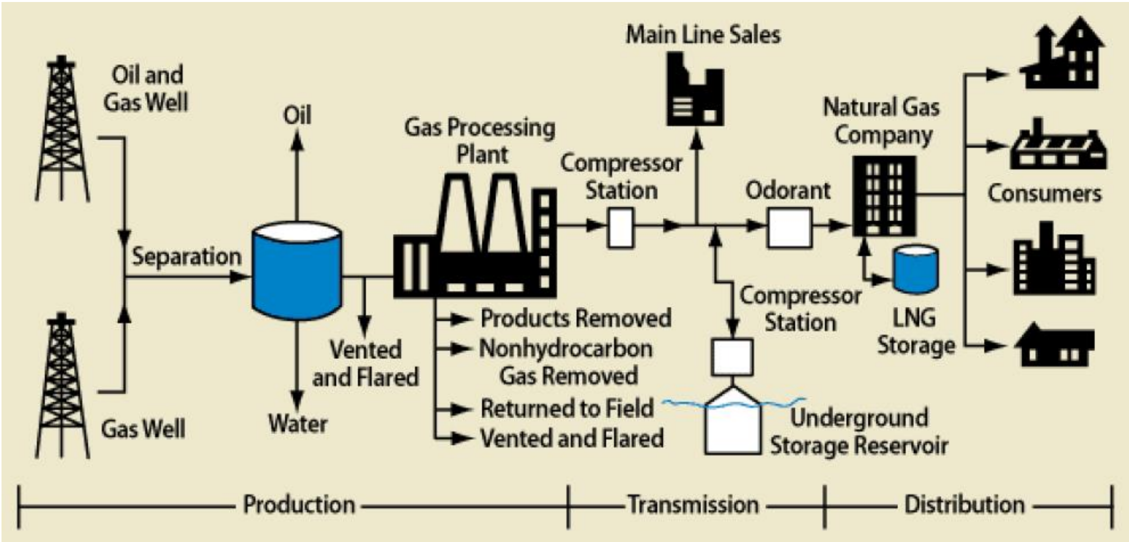
[28] Larry Light. *Why natural gas is the future – not coal.* CBS New, March 15, 2017.

produced an average of 71.1 Bcf of natural gas per day; which amounts to a 20% share of the world's total natural gas production.[29] With a strong infrastructure in place, the only impediment to the United States maintaining a sustained competitive advantage in the natural gas industry is the level of proved natural gas reserved. The U.S. only has proved reserves of 309 trillion cubic feet; whereas Russian and Iran have proven reserves of 1.23 and 1.17 quadrillion cubic feet respectively.

[29] Robert Rapier. *The U.S. Is Still The Global Natural Gas King*. Forbes, July 29, 2018

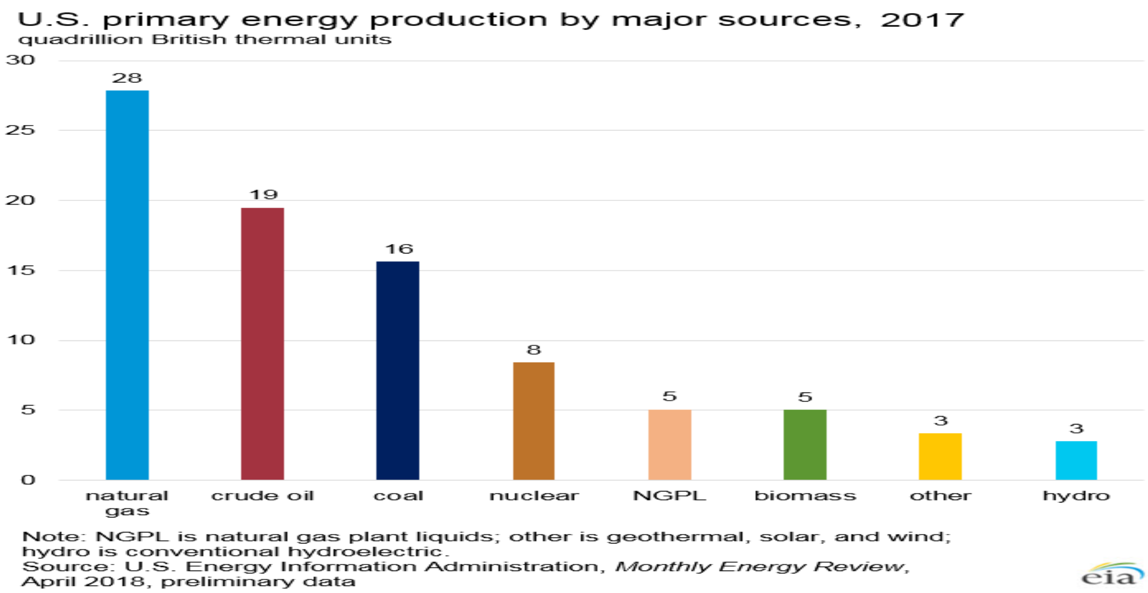
Natural Gas Supply Chain

The US natural gas supply chain consist of upstream, midstream, and downstream functions. Upstream includes drilling and production; midstream includes treatment and transportation; downstream includes industrial, residential and commercial uses.



Energy Production 2017

In 2017, the amount of energy produced in the United States was equal to about 87.5 quadrillion Btu. Natural gas accounted for 32% of energy production.



Summary Statistics for Natural Gas in United States

- U.S. Energy Information Administration

Table 1. Summary of natural gas supply and disposition in the United States, 2013-2018
(billion cubic feet)

Year and Month	Gross Withdrawals	Marketed Production	NGPL Production[a]	Dry Gas Production[b]	Supplemental Gaseous Fuels[c]	Net Imports	Net Storage Withdrawals[d]	Balancing Item[e]	Consumption[f]
2013 Total	29,523	25,562	1,357	24,206	55	1,311	546	38	26,155
2014 Total	31,405	27,498	1,608	25,890	60	1,181	-254	-283	26,593
2015 Total	32,915	28,772	1,707	27,065	59	935	-547	-268	27,244
2016									
January	R2,823	R2,435	R155	R2,280	5	105	741	R-40	3,092
February	R2,654	R2,311	R147	R2,163	5	89	411	R-16	R2,652
March	R2,825	R2,442	R155	R2,287	5	46	53	R-34	R2,356
April	R2,679	R2,362	R150	R2,211	5	63	-171	R-25	R2,084
May	R2,768	R2,412	R154	R2,259	5	60	-337	R-21	R1,966
June	R2,628	R2,312	R147	R2,165	5	59	-229	R1	R2,001
July	R2,721	R2,409	R153	R2,256	5	76	-139	R-11	R2,187
August	R2,723	R2,390	R152	R2,238	5	48	-130	R48	R2,208
September	R2,626	R2,297	R146	R2,151	5	37	-270	R25	R1,948
October	R2,720	2,365	151	2,214	5	55	R-316	R-32	R1,925
November	R2,678	R2,307	147	R2,161	5	3	39	R-48	R2,159
December	R2,747	R2,358	150	R2,207	5	30	688	R-63	R2,866
Total	R32,592	R28,400	R1,808	R26,592	57	671	R340	R-216	R27,444
2017									
January	R2,749	R2,355	R154	R2,202	5	20	R687	R-13	R2,901
February	R2,505	R2,146	R140	R2,005	5	*	R292	R28	R2,329
March	R2,812	R2,431	R159	R2,272	5	9	R281	R-39	R2,529
April	R2,703	R2,355	R154	R2,201	5	-9	R-236	R-34	R1,928
May	R2,787	R2,430	R159	R2,271	R5	-10	R-348	R-22	R1,897
June	R2,693	R2,370	R155	R2,215	R5	-14	R-287	R-8	R1,912
July	R2,764	R2,479	R162	R2,317	R6	2	R-155	R-37	2,133
August	R2,781	R2,478	R162	R2,316	R6	1	R-201	R-17	R2,105
September	R2,767	R2,434	159	R2,275	5	-21	R-323	R-14	1,923
October	R2,907	R2,550	R166	R2,384	R6	-37	R-254	R-62	R2,037
November	R2,884	R2,535	R165	R2,370	6	-45	R90	R-70	R2,351
December	R3,006	R2,635	R172	R2,463	R6	-22	R707	R-88	R3,066
Total	R33,357	R29,197	R1,906	R27,291	R66	-125	R254	R-375	R27,110
2018									
January	RE2,959	RE2,586	171	RE2,416	R6	3	896	R-2	R3,318
February	RE2,724	RE2,385	163	RE2,222	R6	-36	467	R8	R2,667
March	RE3,048	RE2,673	R188	RE2,485	R6	-18	285	*	R2,758
April	RE2,960	RE2,598	184	RE2,414	R5	-35	-32	R-15	R2,336
May	RE3,082	RE2,713	192	RE2,521	R5	-44	-423	R-16	2,043
June	RE2,957	RE2,643	187	RE2,455	R6	R-32	-348	R-30	R2,051
July	E3,108	E2,783	197	E2,586	5	-54	-186	-15	2,336
2018 7-Month YTD	E20,837	E18,381	1,281	E17,099	39	-216	658	-71	17,510
2017 7-Month YTD	19,012	16,565	1,081	15,483	37	-2	235	-125	15,629
2016 7-Month YTD	19,098	16,683	1,062	15,621	34	499	330	-146	16,337

[a] Monthly natural gas plant liquid (NGPL) production, gaseous equivalent, is derived from sample data reported by gas processing plants on Form EIA-816, *"Monthly Natural Gas Liquids Report,"* and Form EIA-64A, *"Annual Report of the Origin of Natural Gas Liquids Production."*

[b] Equal to marketed production minus NGPL production.

[c] Supplemental gaseous fuels data are collected only on an annual basis except for the Dakota Gasification Co. coal gasification facility which provides data each month. The ratio of annual supplemental fuels (excluding Dakota Gasification Co.) to the sum of dry gas production, net imports, and net withdrawals from storage is calculated. This ratio is applied to the monthly sum of these three elements. The Dakota Gasification Co. monthly value is added to the result to produce the monthly supplemental fuels estimate.

[d] Monthly and annual data for 2013 through 2016 include underground storage and liquefied natural gas storage. Data for January 2017 forward include underground storage only. See Appendix A, Explanatory Note 5, for discussion of computation procedures.

[e] Represents quantities lost and imbalances in data due to differences among data sources. Net imports and balancing item for 2014 and 2015 excludes net intransit deliveries. These net intransit deliveries were (in billion cubic feet): 74 for 2017; 70 for 2016; 57 for 2015; 27 for 2014; and 54 for 2013. See Appendix A, Explanatory Note 7, for full discussion.

[f] Consists of pipeline fuel use, lease and plant fuel use, vehicle fuel, and deliveries to consuming sectors as shown in Table 2.

R Revised data.

* Volume is between -500 MMcf and 500 MMcf.

E Estimated data.

RE Revised estimated data.

Notes: Data for 2013 through 2016 are final. All other data are preliminary unless otherwise indicated. Geographic coverage is the 50 states and the District of Columbia. Totals may not equal sum of components because of independent rounding.

Sources: 2013-2017: U.S. Energy Information Administration (EIA), *Natural Gas Annual 2017*. January 2018 through current month: Form EIA-914, *"Monthly Crude Oil and Lease Condensate, and Natural Gas Production Report"*; Form EIA-857, "*Monthly Report of Natural Gas Purchases and Deliveries to Consumers*"; Form EIA-191, "*Monthly Underground Gas Storage Report*"; EIA computations and estimates; and Office of Fossil Energy, "*Natural Gas Imports and Exports*." See Table 7 for detailed source notes for Marketed Production. See Appendix A, Notes 3 and 4, for discussion of computation and estimation procedures and revision policies.

US Natural Gas Underground Storage Report – US Energy Information Administration

As of November 30th, 2018, the United States had 2,991 Bcf of working gas in storage.

Weekly Working Gas in Underground Storage

(Billion Cubic Feet)

Period: Weekly

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Region	Graph Clear	10/26/18	11/02/18	11/09/18	11/16/18	11/23/18	11/30/18	View History
Total Lower 48 States		3,143	3,208	3,247	3,113	3,054	2,991	2010-2018
East		826	831	835	803	778	752	2010-2018
Midwest		956	980	991	959	938	914	2010-2018
Mountain		180	182	181	174	171	168	2010-2018
Pacific		262	265	266	258	254	253	2010-2018
South Central		919	949	974	919	914	905	2010-2018
Salt		234	253	272	251	259	263	2010-2018
Nonsalt		686	696	702	668	654	642	2010-2018

Click on the source key icon to learn how to download series into Excel, or to embed a chart or map on your website.

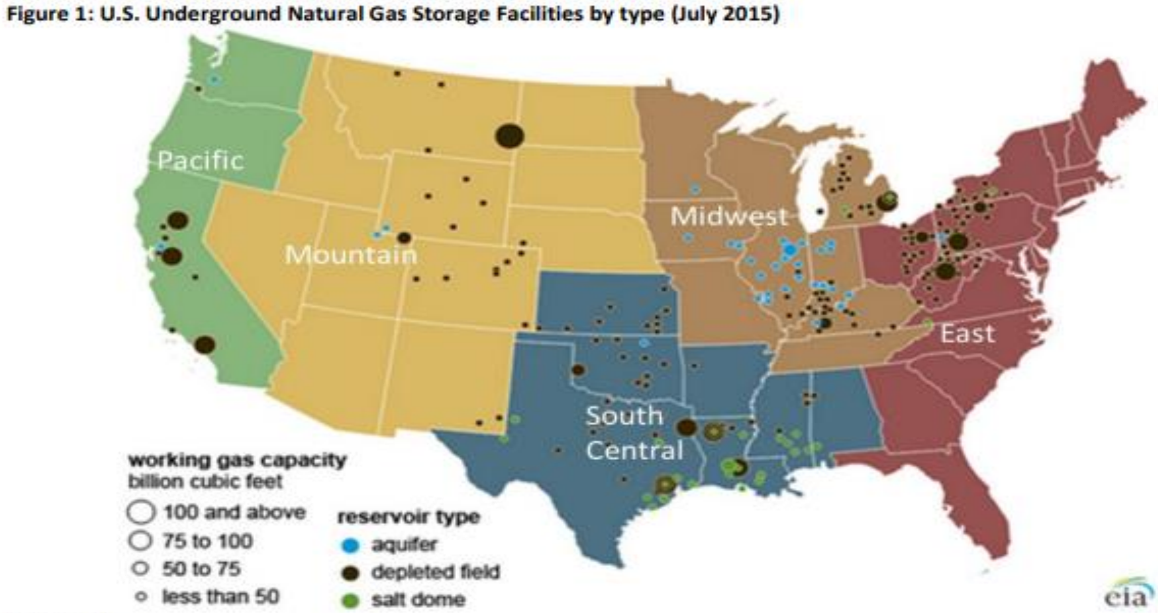
- = No Data Reported; -- = Not Applicable; **NA** = Not Available; **W** = Withheld to avoid disclosure of individual company data.

Notes: This table tracks U.S. natural gas inventories held in underground storage facilities. The weekly stocks generally are the volumes of working gas as of the report date. Changes in reported stock levels reflect all events affecting working gas in storage, including injections, withdrawals, and reclassifications between base and working gas, including information on estimated measures of sampling variability for the most current published estimates of weekly stocks and their net changes. See Definitions, Sources, and Notes link above for more information on this table.

Release Date: 12/7/2018
Next Release Date: 12/13/2018

US Underground Natural Storage Facilities (July 2015)

Figure 1: U.S. Underground Natural Gas Storage Facilities by type (July 2015)



Source: EIA