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Throughout there is an examination of where natural gas and coal pollute, the sources of concern, and how regulation may impact the natural gas and coal industries. With methane emissions being a major concern of natural gas and carbon dioxide emissions being a major concern of coal, a more in depth look at methane and carbon dioxide reduction will be examined. In addition to climate concerns, the paper looks at the impact natural gas and coal have on their surrounding environments through their different stages of life and use. There is a focus on what is needed to ensure greater environmental health, with the knowledge that there is a need for fossil fuels in today's world.

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THE ENVIRONMENTAL IMPACT AND CONCERNS OF NATURAL GAS AND COAL

CHRISTOPHER M. MASON

A thesis submitted for partial fulfillment of the requirements for the degree of Masters in Business Administration in Petroleum Management in the Kansas School of Business

2019

Approved by:

Dr. Shapour Vossoughi

ABSTRACT

Christopher M. Mason
The Environmental Impact and Concerns of Natural Gas and Coal
(Under the direction of Dr. Shapour Vossoughi)

This paper looks at environmental impacts of natural gas and its use as a cleaner fossil fuel, by exploring its environmental impact compared to coal. This will look into the climate impacts associated with natural gas and coal, as natural gas replaces coal as the fossil fuel of choice. A further look into the risks and hazards associated with natural gas and coal will be examined and compared. There is an analysis of what is needed to ensure that natural gas can retain its position of being considered the cleanest fossil fuel in the world.

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Table of Contents

INTRODUCTION

In today's current environment, there is a concern of fossil fuels and their impact on the environment, specifically their impact on climate change. Most commonly when people think of a fossil fuel pollutant, they think of coal. On the other hand, in the recent past, when people have thought of a clean fossil fuel they may have thought of natural gas. With these common thoughts, this illustrates why natural gas energy use is expected to continue to grow in the foreseeable future while coal is expected to continue its decline.

While natural gas is seen as a cleaner fuel solution, its emergence as a go to fossil fuel has coincided with a declining price (see figure 1) (Ritchie) and an increase in United States production (see figure 2) (Advantage Futures). When you combine the factors of cheaper natural gas and newer, cleaner, and more energy efficient natural gas power plants, with the fact that coal is seen as dirty and the average age of a coal plant is 39 years old; it is easy to see why coal is having difficulty maintaining its edge as a leading energy source. (EIA GOV) As the United States continues to push for lower greenhouse gas emissions, climate change solutions, and better water and air quality, the wars on coal and other fossil fuels may have only just begun.

NATURAL GAS AND THE ENVIRONMENT

Environmentally, natural gas is the cleanest burning fossil fuel energy source available. While it is not as clean as solar or wind power, it produces nearly 1/3 less carbon dioxide than coal and 1/2 the carbon dioxide of oil when it is burned. Furthermore, natural gas is relatively cheap and abundant within the United States. While natural gas does produce less carbon dioxide than any other fossil fuel, it does have one major drawback compared to coal when it comes to climate concerns. That concern is the release of methane during its life cycle from

extraction to use. Published reports and studies have claimed that methane is up to 34 times heat trapping than carbon dioxide over a 100-year life cycle and over 86 times over 20-year life cycle. (Myhre)

The effects of whether natural gas or coal would be cleaner for the environment would be based primarily on the ability of natural gas producers to maintain methane leakage from natural gas extraction to use. Preliminary field studies have shown that methane leakage has been between 1 percent and 9 percent of 20-year life cycle emissions. For natural gas to be more advantageous in the climate change debate, methane release must be less than 3.2 percent of total life cycle emissions. (Ramón A. Alvarez)

By using natural gas over coal, power plants would not only cut carbon dioxide emissions by over 50%, they would also cut emissions of carbon monoxide by 90%, sulfur dioxide by 99%, nitrogen oxide by over 80%, particulate matter by 99%, and they would completely cut out mercury emissions. (Encana) With all of these cuts in emissions from burning natural gas over coal, the concern of methane leakage still remains. This concern of methane leakage can be mitigated through the use of current and developing technology that can be used to stop leakage wherever it may occur in the system, from drilling to home service.

With methane currently estimated as contributing approximately 25% of all greenhouse gas effects, this is what concerns climate scientists the most about increasing natural gas production within the country. There is however, a belief that all methane emissions can realistically be decreased by as much as 75%, with 50% of that cut, coming at a little to no cost to consumers and producers. Realistically, the amount of reduction expenses that companies will have to incur, will depend on government policies that may or may not be imposed upon producers. (Siegel) In 2015 it was estimated that 31% of all methane emissions were caused

from natural gas and petroleum systems. (Tonelli) In total, estimates conducted by the US Energy Information Administration (EIA) concluded that more than 8 billion cubic meters of gas are lost between the point of production to when it reaches the home or the final customer. (McKenna)

The other major concern for environmentalist with natural gas has to do with the amount of water and chemicals used to conduct fracking. In 2011, the EPA estimated that between 70 billion and 140 billion gallons of water were used to fracture 35,000 wells in their study within the United States. With this tremendous amount of water along with mixed additives that are used during the fracking process, environmentalists are concern that there is a significant likelihood that drinking water will become contaminated. Additionally, with these large quantities of water usage, many are worried about what the strain will be on local water supplies. Unlike other energy related uses, this water is generally not recoverable. (UCSUSA)

Common contaminants normally associated with fracking wastewater include: bromide, radionuclides, and total dissolved solids. All of which are concerns due to the impact on rivers, groundwater, and downstream water treatment plants, which may not be capable of dealing with these contaminants. Furthermore, it is estimated that between 18 and 80 percent of the fracking fluid injected into a well will return to the surface. This return of water to the surface can be contaminated with the chemical mixtures along with dissolved salts and heavy metals that are deep within the earth. (Stone)

A further concern that must be addressed within the oil and gas industry is the number of earthquakes that are associated with the fracking process. Although the magnitudes of most of the earthquakes are small, the issue is high on the lists of environmentalists. Scientific and governmental research indicate that the earthquakes occur primarily during the fracking process

and secondarily through the disposal of fracking wastewater via underground injection. (Earthworks) From January 2010 to May 2017, the USGS measured 8,908 earthquakes across the state of Oklahoma, the state that is most notable for fracking related earthquakes. (Conca)

An Environmental Defense Fund (EDF) study found that a methane leakage rate of 3.2% from natural gas would result in no climate benefits when comparing coal-fired plants against natural gas plants. (Ramón A. Alvarez) Based on previous studies conducted by the EPA it was assumed that the total methane leakage for natural gas was 1.4%. But newer studies have concluded that this number is closer to 2.3%. This is still beneficial in terms of climate impact, but it is a 60% difference when compared to previous analysis. This 2.3% represents a total of 13 million metric tons of methane being leaked per year between the point of production and the final use. (Colorado State University) Additionally, studies of shale gas sites have found leak rates between 2.2 and 3.8 percent, plus an additional 1.4 to 3.6 percent leakage rate during transport, storage, and distribution. With this rate of leakage, this would make shale gas a bigger contributor to global warming than coal. (Conca)

Throughout the United States there are over 500,000 natural gas wells along with over 2 million miles of piping and millions of valves, fittings, and other component from which leaks come from. Production makes up the majority of natural gas leaks at 37 percent of all leaks followed by the gathering process at 27 percent (see Figure 3). While natural gas that makes it to the average home is 85 to 95 percent methane, the other 5 to 15 percent may contain hydrocarbons that could potentially degrade local air quality or potentially be dangerous to human health. (Ramón A. Alvarez)

There are generally two ways in which experts measure greenhouse gases: the first way is the inventory tally or commonly referred to as the “bottom up” approach and the second way is

the aircraft surveillance or which would be commonly referred to as the "top-down" approach. The bottom-up approach tallies up all of the nation's natural gas equipment and estimates an annualized average emission rate for all and adds them up. This method does not accurately measure equipment records and does not take into account equipment that may have operational errors.

On the other hand, the top-down approach typically requires aircraft and measures methane concentrations upwind and downwind of natural gas geographic areas. An issue with this method is that it captures methane emissions from all activities in the area rather than emissions from just natural gas operations. Another issue with this is that it takes a snapshot in time based on when a plane flies in the area. In general, the top-down approach emission estimates are generally about twice as high as the bottom-up approach. (Ramón A. Alvarez)[11] In reality there should be serious questions about total emission levels for either approach being used, based on their potential for discrepancies.

COAL AND THE ENVIRONMENT

Coal is generally regarded as the most pollutant source of energy, which creates environmental issues through all of its life-cycle stages. Environmental issues related to coal include, but are not limited to air pollution, water pollution, toxicity, acid rain, radiation, and climate change. Coal is generally mined through surface or opencast mining or underground mining. (Hinton)

Even though natural gas exploration is generally more associated with methane emissions, approximately 9% of all methane emissions come from coal mining and abandoned coal mines. (EIA) These emissions are in addition to the greenhouse gas emissions that come

from coal mining. When the methane emissions from mining are added to the pollutants from burning coal, it just adds to the case against coal from an environmental standpoint. In 2017, based on a U.S. Energy Information Administration (EIA) finding, 14% of all energy in the U.S. came from coal, but 26% of all emissions came from coal. On the other hand, natural gas had 29% of all energy and 29% of emissions (See Figure 4). (EIA)

One of the major issues that a lot of environmentalists have against coal plants is that they are generally seen as big contributors to air pollution. When it comes to air pollution, maybe the greatest impact is the fact that coal plants are responsible for 42% of all US mercury emissions, with 45,676 pounds of mercury emitted in 2014, according to the EPA. When considered with the knowledge that $1/70^{th}$ of a teaspoon of mercury in a 25-acre lake can make the fish unsafe to eat, this really get environmentalists concerned. (UCSUSA)

Sulfur dioxide, nitrogen oxides, lead, cadmium, arsenic, and particulate matter are other air pollutants associated with coal burning. In the US in 2014, coal plants emitted more than 3.1 million tons of sulfur dioxide, 1.5 million tons of nitrogen oxides, and 576 thousand tons of carbon monoxide among other things. A lot of the toxins associated with coal burning have been linked to health issues like, chronic respiratory diseases, influenza, heart disease, and cancer. (UCSUSA) All of these toxins are in addition to the massive amounts of carbon dioxide that coal plants emit every year.

Throughout the United States, 107 million tons of coal ash are produced and placed into one of 1425 sites in 37 different states. Out of these 1425 sites, there have been over 200 incidents at these sites leading to contamination of nearby waters. These incidents have ranged from small, all the way to very large and significant waste spills. The biggest coal ash waste spill occurred in Tennessee in 2008, when 1.1 billion gallons of coal ash slurry spilled from the

Kingston, TN coal plant dam, polluting the Emory and Clinch Rivers. This spill came with cleanup and economic costs in the range of $3 billion. (Earth Justice)

From 2003 to 2015 over 200 coal fired power plants were shutdown. In order to fill this loss of energy in the power grid, there has been an increase in natural gas plants, along with an increased reliance on renewable energy sources (See Figure 5). Natural gas is the one fossil fuel that is considered to be a cleaner burning fossil fuel, but there are still groups that are opposed to its use. The rise in natural gas can also be attributed to the fact that since 2006, natural gas has been the cheapest fossil fuel to use based on a global price index of fossil fuels (see figure 1). (Ritchie) This can be attributed to the fact that the U.S. has dramatically increased production by over 25 billion cubic feet per month, since 2006 (see figure 2). (Advantage Futures)

With this shift from using more coal to more natural gas over the past few decades, this has meant that CO2 and greenhouse emissions have fallen over that course of time based on per capita gross domestic product (GDP) and per individual (see figure 6). (EPA) Additionally, although total emissions have grown by 7% from 1990 to 2014, greenhouse emissions have actually fallen by 7% if compared to 2005, right about the same time natural gas had become a cheaper fuel to use as compared to coal and oil. From 1990 to 2014, greenhouse gas emissions declined by 40% based on per dollar of goods and services produced in the U.S. economy, showing that the United States is becoming more efficient with respect to the environment in energy production. (EPA)

Not only does the use of coal contribute to air pollution, but it also has major health concerns when it comes to the people that mine coal. Since, 1970 there have been nearly 4,700 cases of progressive massive fibrosis (PMF), which is the aggressive type of what is commonly called black lung disease associated with coal workers. The overall number of workers

diagnosed with black lung disease or coal-workers pneumoconiosis have steadily decreased since 1999 at 409 workers to a low of 112 in 2016. However, during this period the years of potential lost life expectancy has increased from 8.1 years of life lost to 12.6 years of life lost in 2016. This can be due to an increase of PMF rates when it comes to black lung disease, which has gone from below .4% in the mid to late 1990s to over 3.0% from 2008-2012. (Boyles)

The 107 million tons of coal ash produced annually, is nearly equivalent to 40% of all municipal waste generated by all Americans. Coal ash contains the residue from coal plant scrubbers, which puts the toxins in the ash vice the air. The risk of coal ash is the potential threat that it presents to waterways. (G. Weismann) Of that previously stated 107 million tons, 47 million tons of that was left over as waste and not used for other industrial purposes. In the United States there are 36 coal ash ponds that are located within the Federal Emergency Management Agency (FEMA) 100-year flood zones. (G. a. Weismann)

REGULATORY IMPACTS ON NATURAL GAS AND COAL

Anytime that one deals with looking at the environmental impact of fossil fuels, one must look at what type of regulation may impact the use of a given resource. The main regulations to look at stem from the creation of the Clean Air Act (CAA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), and the Endangered Species Act (ESA). These become important because they can dictate how coal or natural gas may be extracted or used. As the world becomes more environmentally conscious, the use and production of natural gas and coal may be impacted as much by a new regulation as they are by supply and demand issues.

With hydraulic fracturing becoming more and more common within the United States over the past 20 years; this puts the process of underground injection of fluids onto the radar of

environmentalists who want more oversight of the process. One way to regulate this, would be to push for the EPA to regulate it under the SDWA. Currently, the EPA does not have the authority to regulate hydraulic fracturing operations under the SDWA due to the Energy Policy Act of 2005, except in situations where diesel fuels are used in the fracturing fluids. Even though the EPA does not currently have the authority, there has been legislation in Congress over the past couple of years that would have given the EPA greater authority to regulate under the SDWA if passed. (Tiemann)

In 1970, the passing of the CAA changed how industries and power plants operate. Though the CAA started out by regulating pollutants like, nitrogen oxide and sulfur dioxide put into the environment, it has since evolved into an act that regulates other greenhouse gases like carbon dioxide and methane. The regulation of carbon dioxide and methane, puts coal powered plants and natural gas extraction into the target zone of the CAA. (Salzman) Some of these regulations can be seen in the unveiling of the Clean Power Plan (CPP) in 2015 through delegated authority in the CAA.

In 2017, the CPP was repealed with the changing of presidential administrations, but the context of the law and the repeal are currently going through litigation. If the CPP rules were to go in place, that would mean methane emissions would be slashed by 40-45% as well as a lifecycle leakage rate of 1.5%. Furthermore, the CPP would aim to cut carbon dioxide emissions nationwide by 32% by 2030, based on 2005 levels. With regulations like the CPP, this would mean that the natural gas industry would have to change how they handle natural gas from source to consumer and would create a dilemma for coal plants in how they control carbon dioxide emissions. (Hausfather)

Through the CWA, the EPA regulates the discharge of pollutants from any point source into navigable waters or waters of the United States (WOTUS). The discharge of these pollutants is controlled by the National Pollutant Discharge Elimination System (NPDES) permitting system. Where this would impact natural gas and coal would be in its creation and disposal of any wastewater that may find its way into navigable waters or WOTUS from natural gas or coal operations. The CWA also prohibits the discharge of wastewater pollutants from onshore unconventional oil and natural gas extraction facilities to a publicly owned treatment work (POTW), which means in some ways that the CWA dictates how the natural gas industry handles its waste. (Salzman)

Though the CWA may impact the natural gas and coal industries in manageable ways today, the way of doing business could be impacted in unforeseeable ways through the passage of regulations like the Clean Water Rule (CWR), which was signed into law under the Obama Administration and has since been repealed by the Trump Administration. However, due to intricacies in the Administrative Procedures Act, this has kept the CWR in place as ongoing litigation is still in play.

When it comes to the ESA, the natural gas and oil industry as well as coal the industry need to be extremely proactive about the potential impacts of a listing under the ESA. Under the ESA, the Fish and Wildlife Service (FWS) must list a species if it finds that "natural or manmade factors" make the species endangered or threatened and cannot consider the potential economic consequences of listing a species. This interpretation has been upheld in courts through cases like TVA *v*. Hill, where the courts have ruled that Congress intended endangered species to be afforded the highest priorities. (Salzman) Outside of proactive action plans to ward off listings to the ESA, companies only other alternative to some of these listings is to go through a permit

application to the Endangered Species Committee. This cabinet-level committee can vote to exempt federal action if it determines that there are no "reasonable and prudent alternatives," the benefits of the action "clearly outweigh" the environmental cost, and the action is of "regional or national significance." (ESA)

When the ESA was passed in 1973 there were less than 400 species listed, today there are over 2100 plant and animal species on the list, with over 1,500 of those, being found in the United States. An example of the ESA impacting oil and gas exploration can be seen in the American Burying Beetle, which was listed in 1989 and has impacted exploration operations ever since in Oklahoma. Twenty years after the listing, actual field data showed that there were more than 72,000 of these beetles in Oklahoma alone: information that may have kept it off of the endangered list. (110-114) The American Burying Beetle, which is still an issue in Oklahoma, could have possibly been prevented if the evidence of the 72,000 beetles had been found sooner. In some ways it is easier to keep a species off of the list rather than waiting for it to get put onto the list and then trying to get it off. The ESA uses the best scientific and commercial data available when it makes its decision on a species. (Salzman) So, if an industry were trying to do work in an area that may have a potential ESA candidate, that industry would be wise to help the FWS determine if that species is actually endangered or threatened.

NATURAL GAS INCIDENTS AND STUDIES

Since natural gas has to be transported or shipped to its destination there is always an opportunity for an accident or a potential environmental disaster. These disasters range from leaks to explosions. During a 2013 study by the Manhattan Institute it was found that hazardous liquid pipelines had the lowest number of incidents at 0.58 serious incidents per billion-ton miles, followed by 0.89 incidents per billion-ton miles for natural gas transmission. Both of

these were lower than the 2.08 incidents per billion-ton miles for rail. During this study it was found that road transportation was severely higher in terms of the number of incidents per ton mile at 19.95 incidents. (Furchtgott-Roth)

Even though companies are generally safe when it comes to gas and oil production and transportation, there are occasional accidents that do happen and when they do, they can often be fatal. In 2014, fatalities in the oil and gas industry hit a peak of 141 nationwide deaths. In addition to these deaths, on average annually, there are 17 residential fatalities and $133 million in property damage from incidents involving natural gas pipelines. (Hand)

Over a 112-day period between 2015 and 2016, an estimated 109,000 metric tons of methane was emitted after a natural gas well ruptured near Porter Ranch, California at the Aliso Canyon gas field. This is considered the biggest methane leak from a natural gas well leak. From this leak Southern California Gas Company has agreed to pay over $130 million in settlements related to the disaster. (Diep) This 109,000 metric tons of methane is equivalent to 9,156,000 metric tons of carbon dioxide. This number may seem low when compared to the total of 6,870 million metric tons in carbon dioxide equivalents produced each year, but from one incident it is a rather large number. (EPA)

With natural gas there are a lot of concerns about the safety and environmental aspects of fracking associated with oil and gas production. Outside of the concern for earthquakes, there is a large concern about the impact of the chemicals that are used in the process of fracking in addition to spills during different phases of the production. Even though chemicals make up less than 1% of the water, some of that 1% is suspected to have toxic chemicals that may be harmful to nearby water sources.

In a survey that studied spills in Colorado, New Mexico, North Dakota, and Pennsylvania, it found that up to 16% of hydraulically fractured wells spilled liquids every year. In this study it was found that most spills occurred within the first three years of a well's life. The majority of the spills are associated with tanks and flowlines (see Figure 7). (Gardiner)

When it comes to spills, the rate of spills varies by states, primarily due to reporting requirements. From 2005 to 2014 researchers found that there were 6,648 spills between the states of North Dakota, Pennsylvania, New Mexico, and Colorado, with North Dakota accounting for nearly two thirds of all spills. This discrepancy can be attributed to the fact that North Dakota, requires a spill be reported if it is larger than 42 gallons, while in Colorado and New Mexico, the reporting requirement is 210 gallons. The good news about the North Dakota number is that 70% of all the spills in the state in 2013 were contained to the well pad and never reached land or water. (McGrath)

In different studies it has been found that children living near oil and gas wells have had increased risks of developing cancer. Additionally, other studies on this have found evidence of higher birth defects in pregnant mothers near areas that have a high density of natural gas wells. Even though there are studies indicating possible birth defects and higher cancer rates among children, a lot of these studies are not conclusive enough and do not seem to be statistically valid to give a definitive answer to the question. On this a Colorado Department of Public Health and Environment (CDPHE) report stated, "at this time, results from exposure and health effect studies do not indicate the need for immediate public health action, but rather indicate the need for more detailed exposure monitoring and systematic analysis of health effects of residents living near oil and gas production." (Gardiner)

When looking at the environment and natural gas production and distribution, you have to look at the age of the infrastructure that is being used throughout the country. While most of this infrastructure is relatively new in the fracking regions, it can be overly aged in regions that were developed decades ago. Throughout the country there is a pipeline network of around 3 million miles that link production areas and storage facilities to consumers. Approximately 305,000 miles of these pipelines are high-pressure transmission and gathering pipelines. This network is used to deliver 25 trillion cubic feet of natural gas to 75 million customers. Out of all this, over 40% of all oil and natural gas infrastructure is over 50 years old (see Figure 8). With an aging infrastructure like this, the industry will have to worry about future maintenance costs and as well as possible environmental costs. These costs may be associated with a deteriorating infrastructure as well as long-term corrosion issues that have caused countless incidents throughout the history of working with oil and gas. (Wirfs-Brock)

NATURAL GAS GROWTH AND STORAGE

Throughout the United States, over the past ten years, there has been a growing push to cleaner and safer energy production within the country. Even though the use of fossil fuels is becoming more and more criticized, it is still our number one source of energy. Since wind power and solar power are not viable options in supplying the energy needs for the entire country and since many are very weary of nuclear power, the natural fossil fuel of choice, due to its cleanliness, is natural gas. The United States is currently the fastest growing producer of natural gas and is expected to continue growing a fast rate until 2040. The only region in the world that is expected to grow their natural gas production more than the United States is the Middle East as a region. With the United States expected to grow production by just under 30 billion cubic

feet per day and the Middle East growing by slightly more that 30 billion cubic feet per day (see Figure 9). (Mills)

As natural gas production and extraction continue to increase, it can be expected that storage for natural gas will need to continue to increase as well. Natural gas is generally stored to even out the production rate of natural gas throughout the year since it's use increases during the winter heating season as well as a natural guard against supply disruptions that may occur. Currently, the primary means of storage for natural gas is in underground storage facilities. There are three main types of underground storage: depleted reservoirs, aquifer reservoirs, and salt caverns. There are around 120 entities that operate approximately 400 storage facilities located throughout the United States (see Figure 10). (Jellicoe)

With all of these storage facilities around the country, comes the concern of their impact on local areas. The primary concern of these facilities is that they will emit methane into the atmosphere as well as having methane leakage contaminating the groundwater. Added to these concerns, is the possible negative impact that these underground facilities have on property values in surrounding communities. There have been studies that the closer one is to a storage facility or the bigger the facility, the more property values decrease for local residents. (Jellicoe)

CONCLUSION

The energy field has been calling natural gas the bridge energy between a world of fossil fuels and renewables. However, some environmentalists are not happy with this claim, since they claim that no fossil fuel is clean. But as a country, the United States has been moving further and further from fossil fuels and it seems as though it will only be a matter of time before natural gas starts to feel the backlash that coal has felt over the past two decades. From 2000 to

2017, fossil fuel electrical generation in the United States has gone from 71 percent to 63 percent. Not a surprise to most people, most of this fall is due to coal's share of electrical generation going from 51 percent to 30 percent in the United States. Natural gas has been a natural beneficiary of this in addition to renewables, which have gone from 16 percent to 32 percent during that time frame. (Rapier)

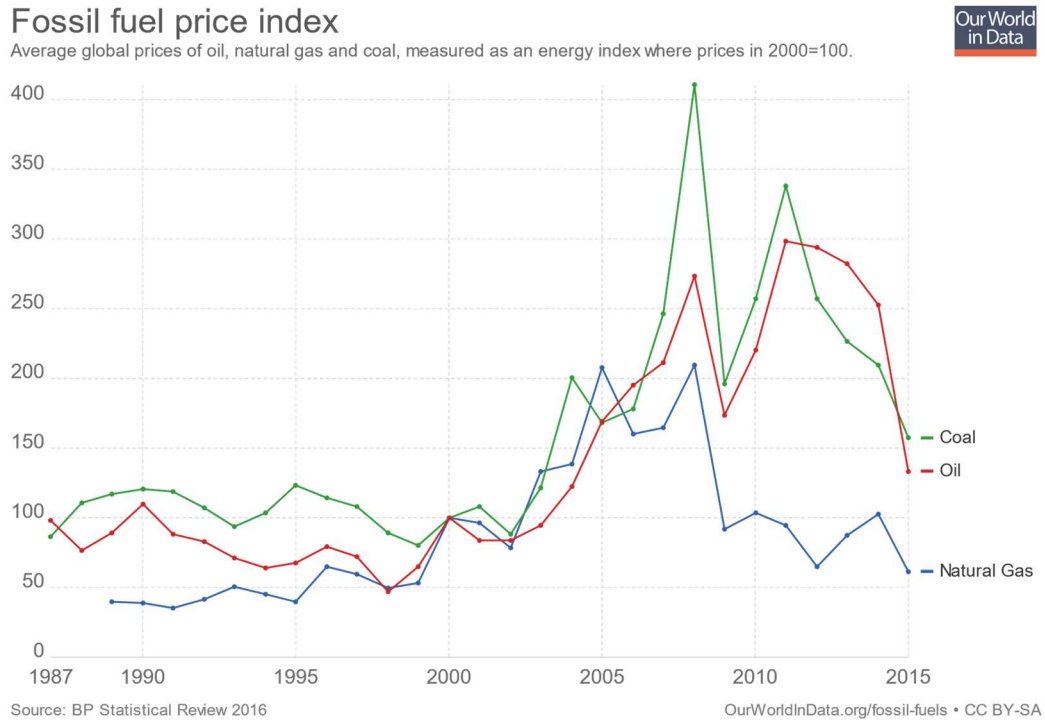
Annual Carbon dioxide emissions throughout the United States have decreased by 639 million metric tons since 2000, but there is a sense that this decrease could easily be more with proper corrective action. One way that environmentalists think this could come down is by limiting the amount of flaring that occurs in the United States. As of 2016, the United States had the most flares at 6,292, in which those flares burn off 10.65 billion cubic meters of natural gas. Also, as of 2016, Russia led the world in burning off nearly 20 billion cubic meters of natural gas, but they did this with only 1,738 flares. (Magill) With this wasting of a natural resource, it has many concerned about how companies or industries are preserving non-renewable resources on earth.

Even though there are environmentalists that will never get onboard with any fossil fuels, there are those environmentalist groups that have agreed that natural gas is a path to a cleaner environment. The Natural Resources Defense Council (NRDC), who may best be known by non-environmentalists as the plaintiff from the 1984 Supreme Court case, NRDC v. Chevron, (who was involved in this case that established a precedence, which is often used today in administrative law, to give deference to agencies like the EPA), has spoken positively about natural gas in the past. Kate Sinding, a senior attorney with the council, when speaking of reducing energy demand and promoting renewables stated, "there is inevitably going to be a role for natural gas to play." Additionally, members of the NRDC have specified that they would like

to see United States coal plants converted to natural gas. (Gardner) Common sense reactions from some of the staunchest fossil fuel critics show a growing support for natural gas as a more environmentally friendly way of improving the environmental quality of the world.

FIGURES

Figure 1



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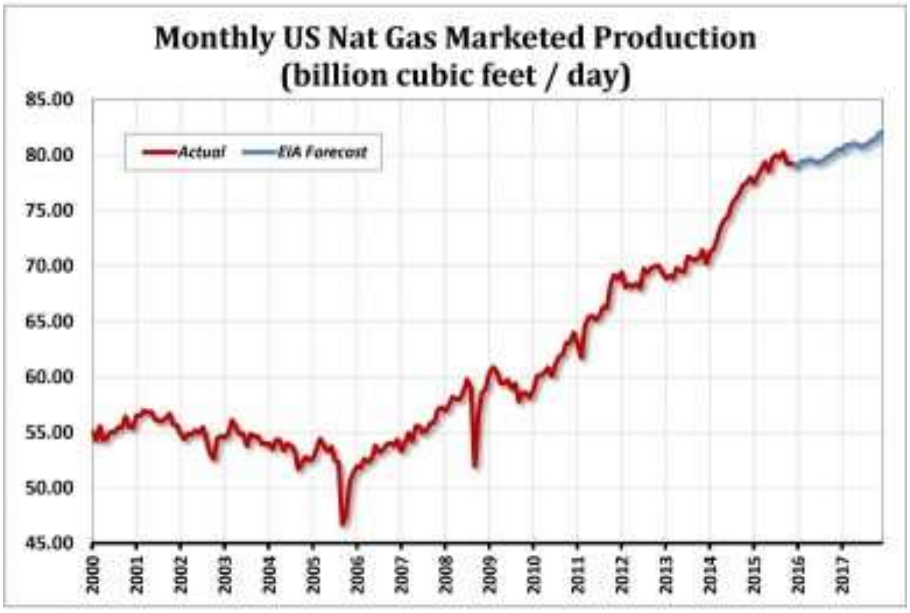

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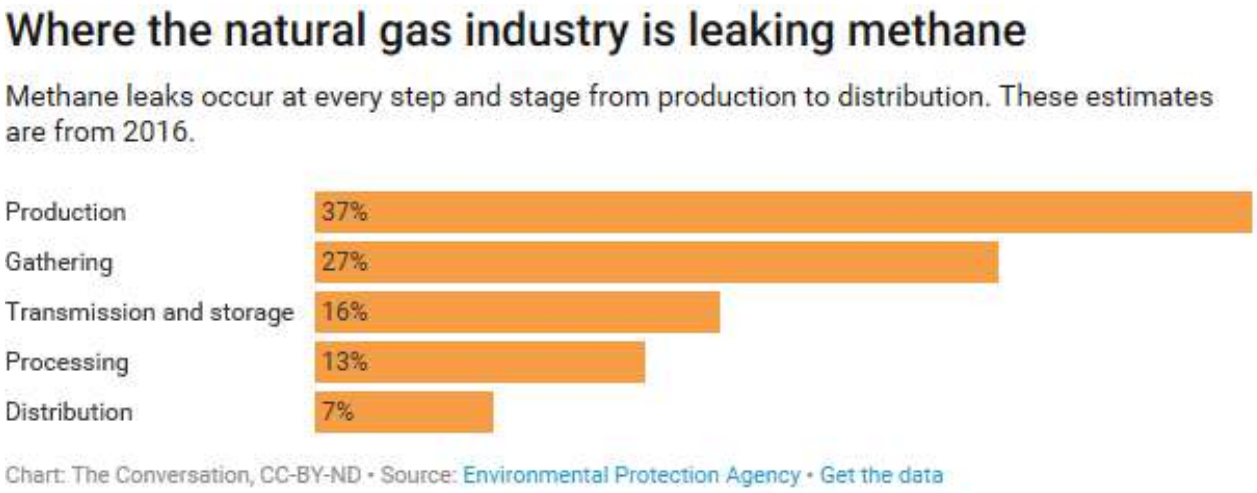

Figure 4

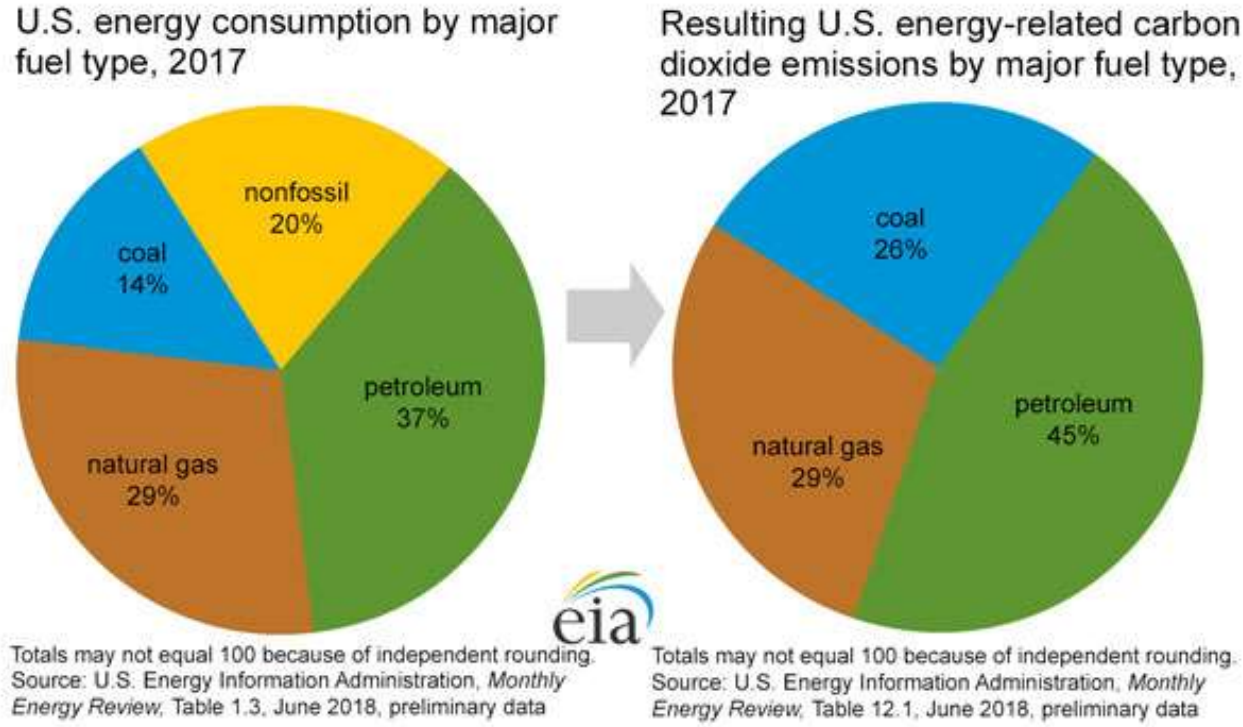

Figure 5

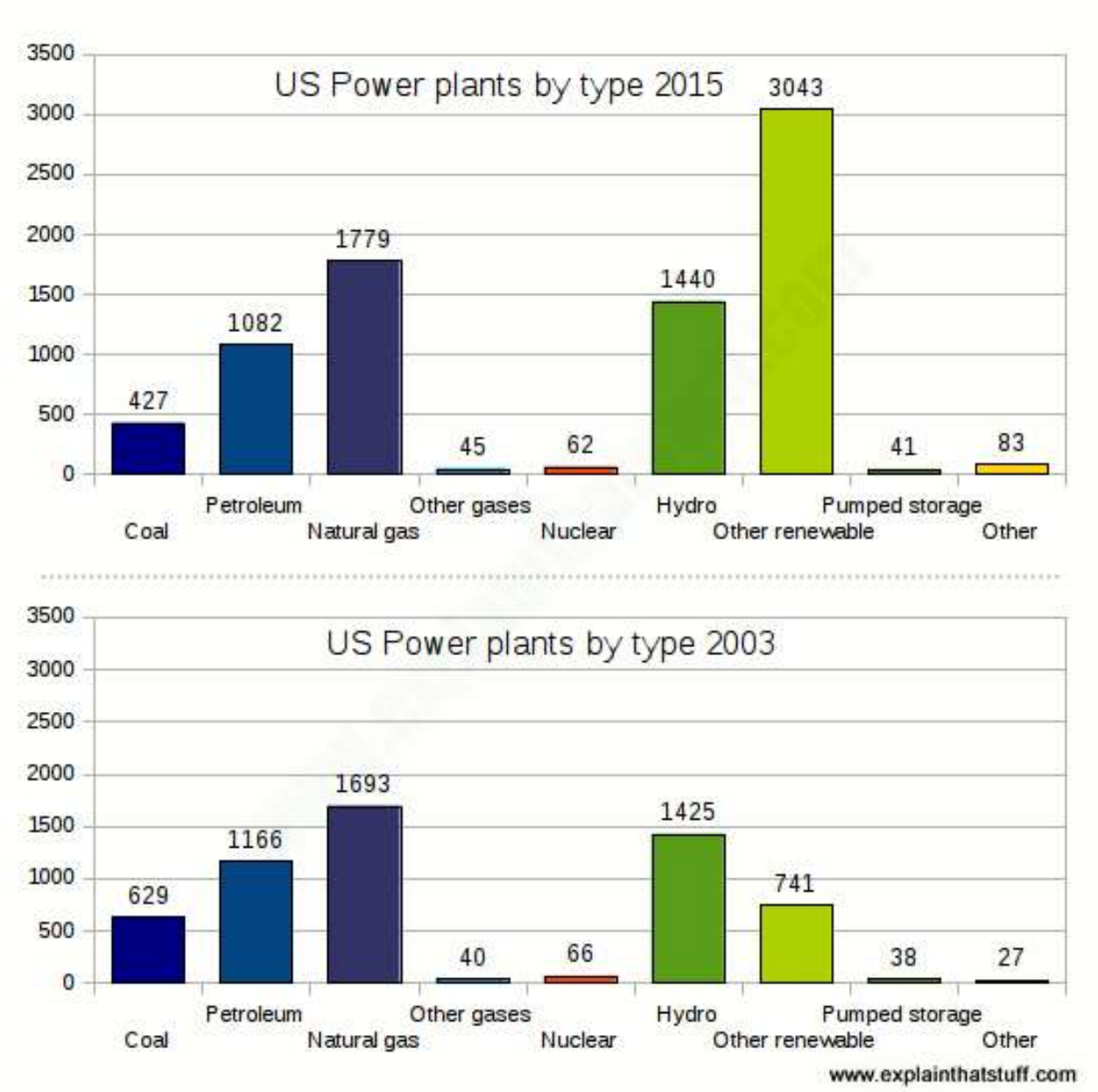
US Power plants by type 2015
3500
3000
2500
2000
1500
1000
500
0
427
1082
1779
45
62
1440
3043
41
83
Coal
Petroleum
Natural gas
Other gases
Nuclear
Hydro
Other renewable
Pumped storage
Other
US Power plants by type 2003
629
1166
1693
40
66
1425
741
38
27
www.explainthatstuff.com

Figure 6

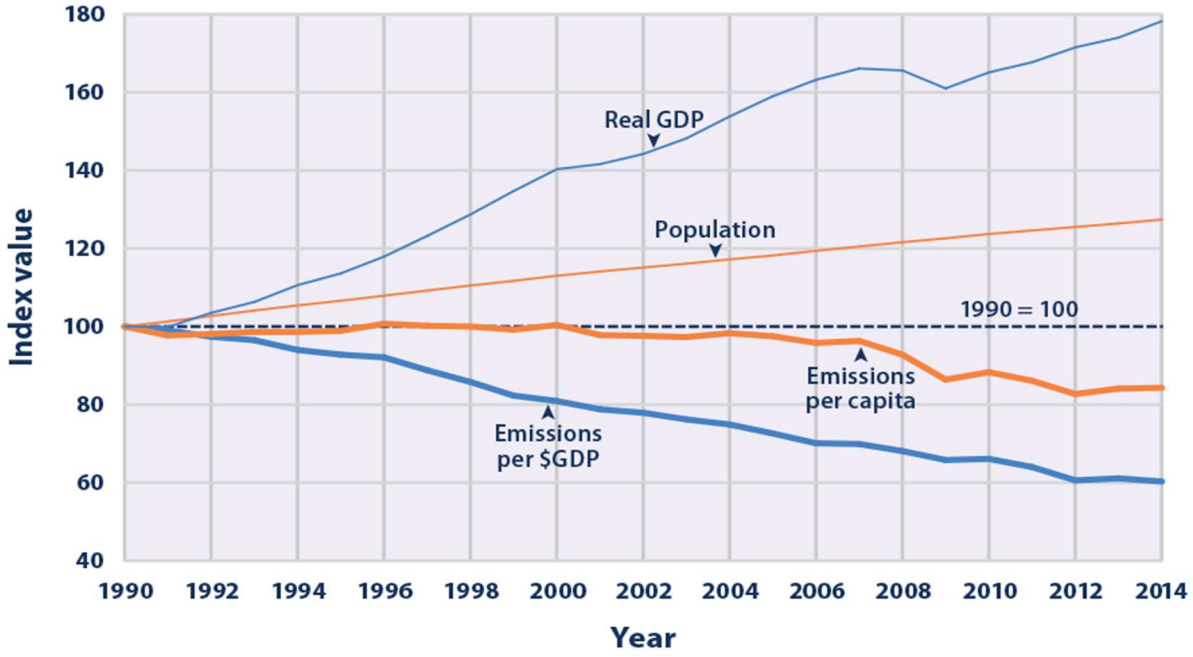

Figure 7

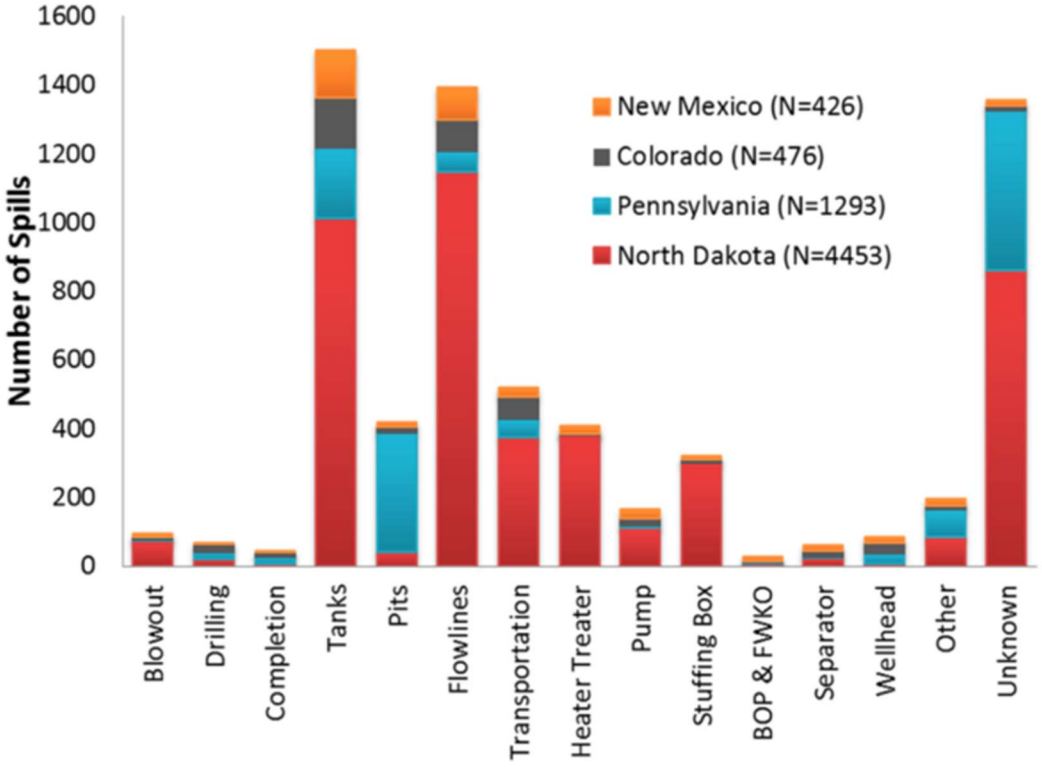

Figure 8

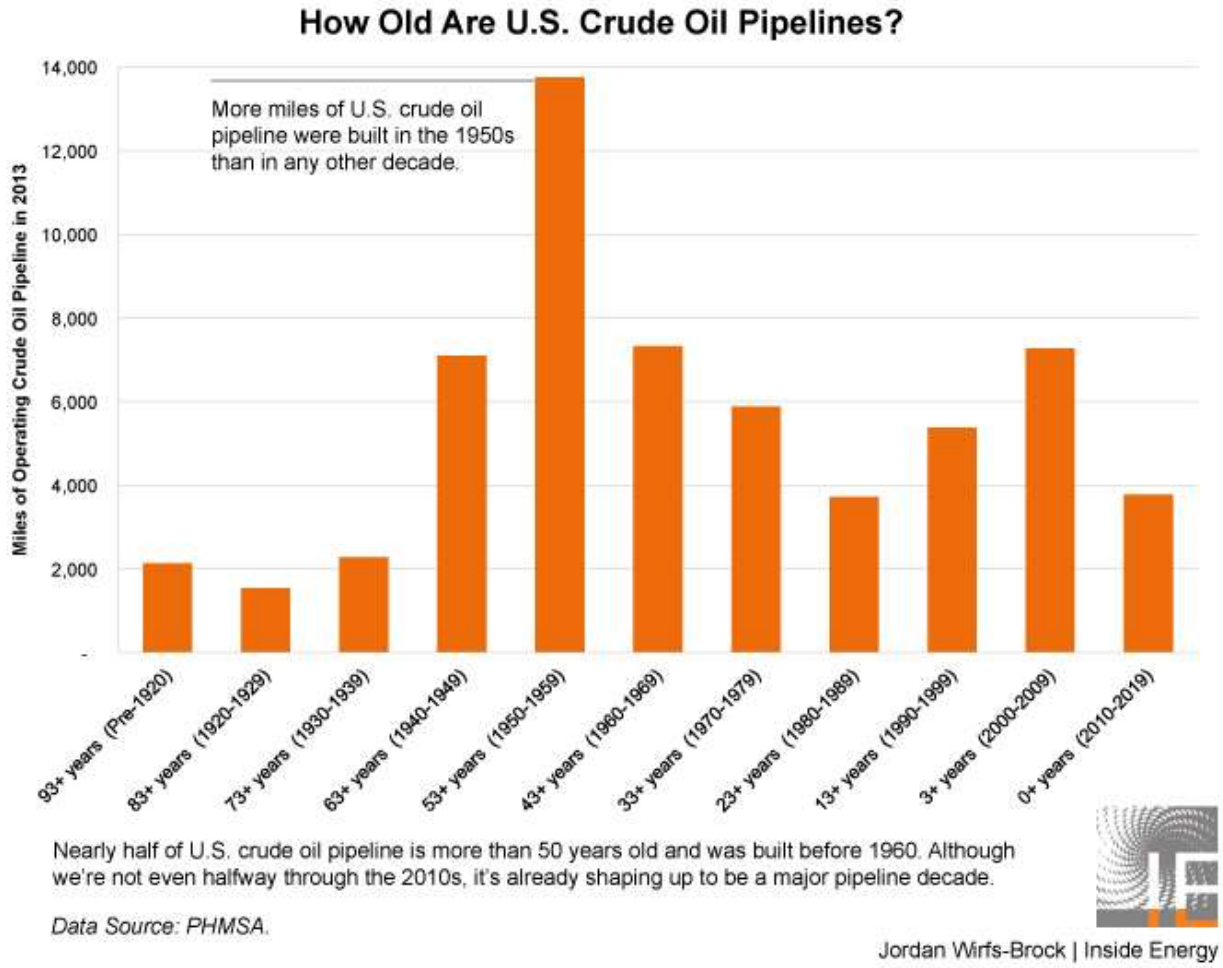
How Old Are U.S. Crude Oil Pipelines?
Miles of Operating Crude Oil Pipeline in 2013
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
More miles of U.S. crude oil pipeline were built in the 1950s than in any other decade.
93+ years (Pre-1920)
83+ years (1920-1929)
73+ years (1930-1939)
63+ years (1940-1949)
53+ years (1950-1959)
43+ years (1960-1969)
33+ years (1970-1979)
23+ years (1980-1989)
13+ years (1990-1999)
3+ years (2000-2009)
0+ years (2010-2019)
Nearly half of U.S. crude oil pipeline is more than 50 years old and was built before 1960. Although we're not even halfway through the 2010s, it's already shaping up to be a major pipeline decade.
Data Source: PHMSA.
Jordan Wirfs-Brock | Inside Energy

Figure 9

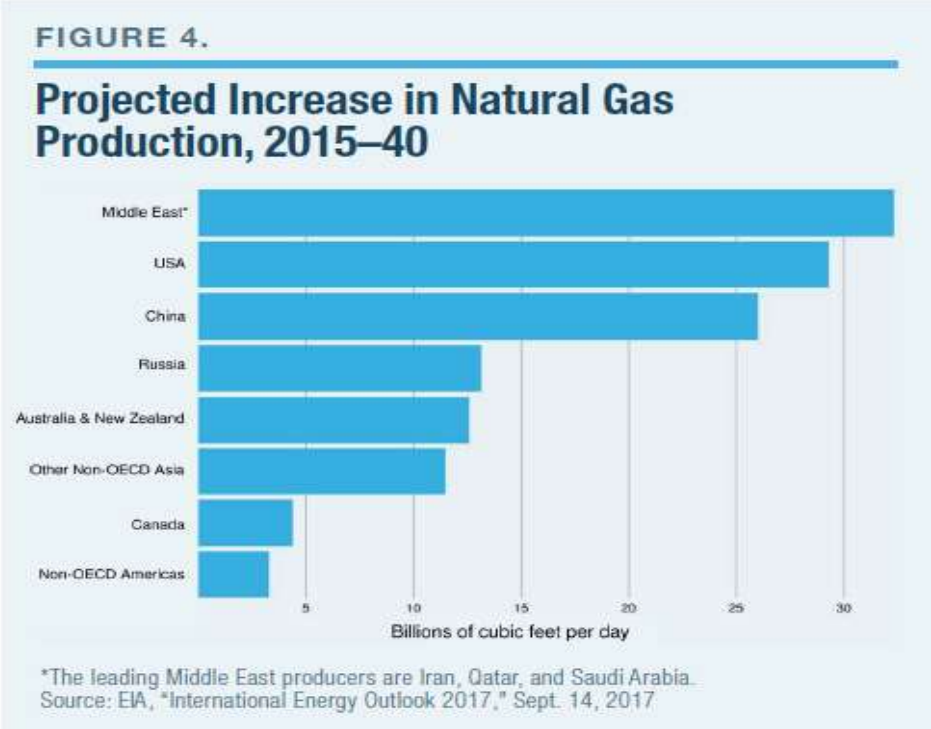

Figure 10

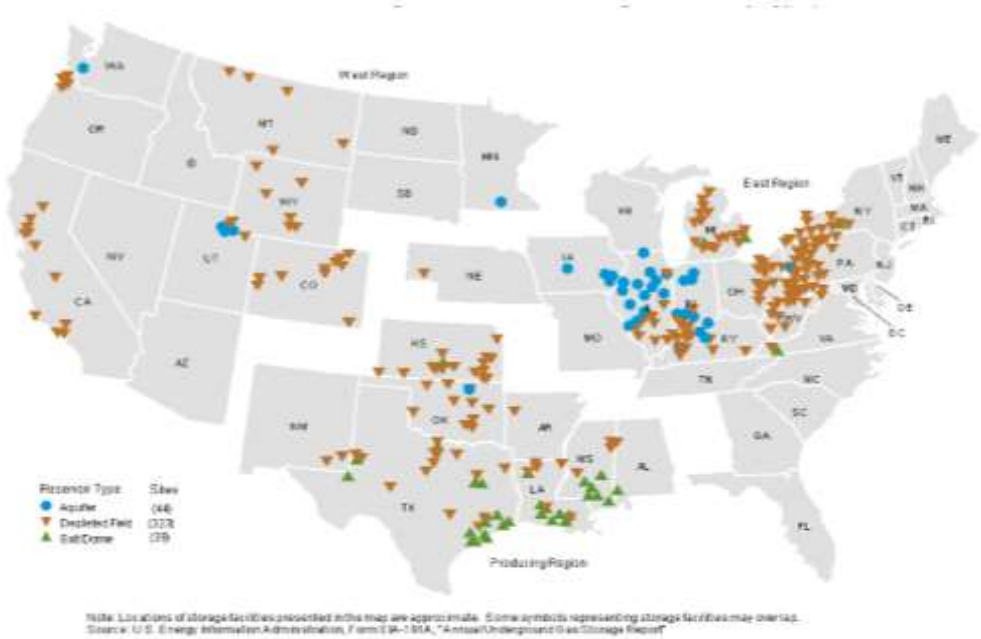

Figure 1. U.S. Lower-48 States Active Underground Natural Gas Storage Facilities by Type (December 31, 2012; US EIA 2012).

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