FRACKING

Numerous items appearing in variety of media both pro and con but all use the buzz words of fracking

News Articles

Is Fracking Safe

Against fracking facts -

Fracking Is Dangerous To Your Health -- Here's Why

The Environmental and Social Impacts of Natural Gas **Fracking**

A New Low in the Media's War on Fracking

Fracking Really Isn't So Bad

To Frack Or Not To Frack

Evidence Against Fracking Accumulates: Almost A Molehill!

Six Reasons Fracking Has Flopped Overseas

Clinton And Sanders Are Pandering To Voters On Fracking

Some of articles are not distortions of the truth
Most give a heavily biased one side of the story

Water Contamination May Well be Widespread Due to Fracking

Effects Of Fracking | Public Lands Are At Risk

Who's Paying The Bills? | The War On Fracking | Anti-Fracking Activists

How America's 'most reckless' billionaire created the fracking boom ...

Fracking Is Dangerous To Your Health -- Here's Why - Forbes

Fracking Has Its Costs And Benefits -- The Trick Is Balancing ... - Forbes

Fracking As The Next Financial Meltdown (Or Not) - Forbes

A New Low in the Media's War on Fracking - Forbes

Fracking-Induced Earthquakes Generate Anxiety In The Public - Forbes

Others are exaggerations of the facts –
Many are light on facts and are flexible in their sources

Poorly regulated oil and gas drilling

In the past their was poor regulation or control over oil exploration– it was a get rich quick opportunity

LOS ANGELES 1930

Drilling was so intense and poorly regulated that the native salmon were wiped out

Today oil derricks stand like trees in a forest…. Steam pile drivers roar on many a vacant lot … 180 permits to drill for oil have been given and 25 more are in procedure …. If this fever continues, as it gives every indication of doing, one reasonably may expect to see virtually the entire water-front line of private properties from Washington street to 66th avenue or Playa del Rey dotted with a line of oil derricks. --"Venice Battle Attests Oil and Water Do Mix," LA Times June 29, 1930

The new look of oil/gas drilling

Today the drilling is in close proximity to homes; but, residents are typically receiving some royalty fee for agreeing to have their land and its subsurface resources mined; 12.5% -- 18% royalty

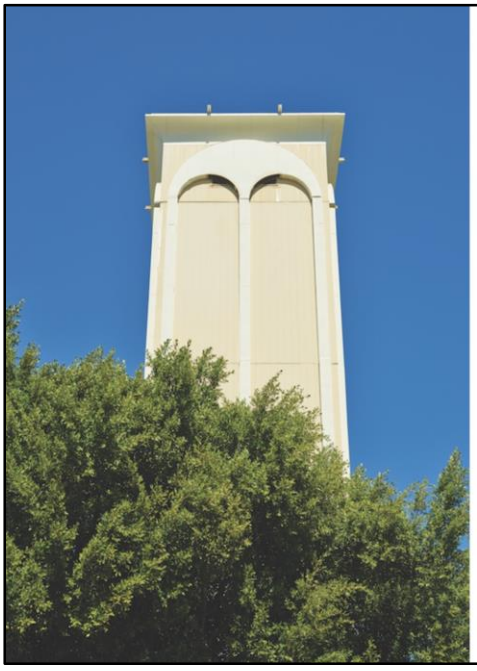
Resolution 112 on Colorado ballet was just defeated which would have banned oil operations within 2500 feet of a residential area

Colorado moved up to now surpassing California in oil/gas production

Typical set-up with a fracking planned; lots of equipment and pumping trucks;
Three primary players –
INVESTOR (speculator), puts together a project, determines risk, acquires leases
CONTRACTOR brings in equipment; making-hole, gets it done; shortest time least cost
OPERATOR (owner) manages production, sells product, determines if/when more fracking

-Built in 1967,
-Windowless beige office building on Pico in the Mid-Wilshire neighborhood hides 52 oil and gas wells
-Owned by Sentinel Peak Resources.
-A derrick on tracks moves from well head to well head within the roofless structure

California operators have reduced the objections of close neighbors by camouflaging their operations

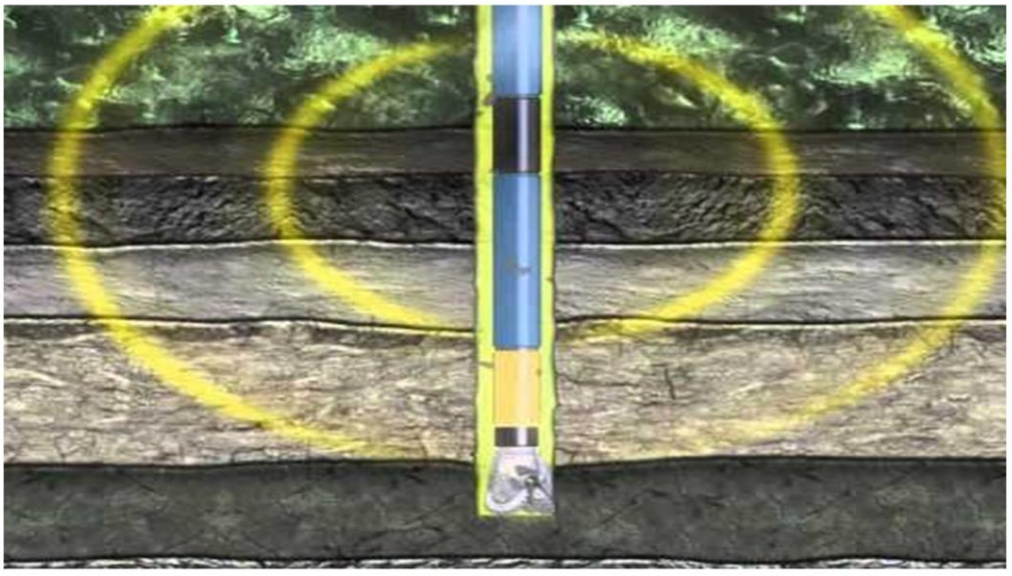


-The Pico & Cardiff; a Jewish enclave since 1945
-Occidental Petroleum disguised this drilling site as a synagogue in 1966.
-Rebuilt in 2001, (Pacific Coast Energy) –Hides 40 wells, which are accessed by a movable derrick that taps the oil field.

The visual appearance has significantly change the NIBY reaction

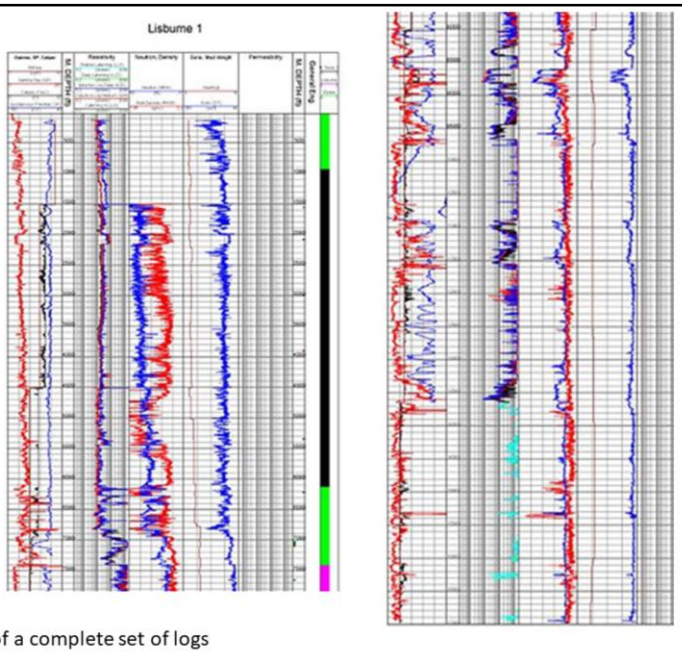
Vertical Drilling and Fracking of the past

Fracturing as a method to stimulate shallow, hard rock oil wells dates back to the 1860s. It was applied by oil producers in Pennsylvania, New York, Kentucky, and West Virginia by using liquid and later also solidified nitroglycerin. Later, the same method was applied to water and gas wells. The idea to use acid as a nonexplosive fluid for well stimulation was introduced in the 1930s. Due to acid etching, fractures would not close completely and therefore productivity was enhanced.



This short clip illustrates the conventional vertical drilling for oil/gas.

Wire line logging record to show if there is commercial opportunity for hydrocarbons



Wireline log consisting of a complete set of logs

My experience in Rockies; our drilling probabilities were running about 1 in 10 for an off-set well; about 1 in 60 for a bonanza well
First the geologists determine a likely opportunity from records on file and knowledge of the sub-surface layers
Typically geophysicist would do a subsurface assessment to refine the prospecting

First vertical drilling only for oil or water

The first commercial oil well 1859, Edwin Drake

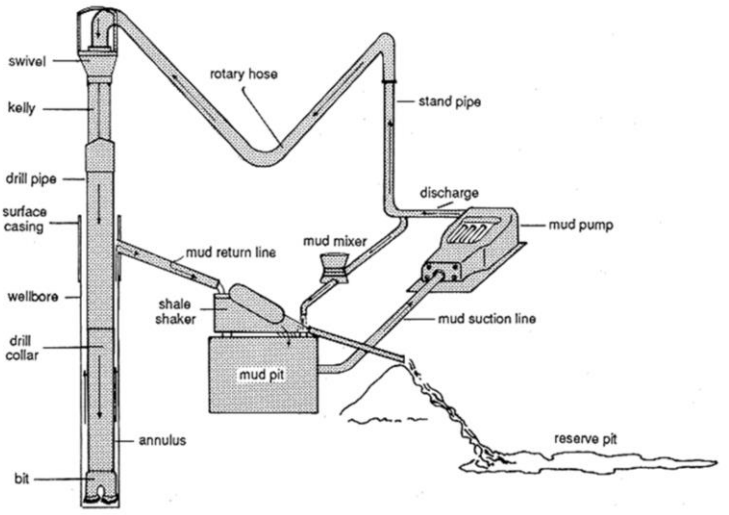
1930 there was use of nitroglycerin to get an oil well producing again

1949, Halliburton Oil Well Cementing Co did a SUCCESSFUL HYRAULIC FRACKING in Oklahoma and in Texas; PATENTED their process; their fracking was to try and get the well producing at the same level as in prior years

Typical rig at a Wyoming drilling site today

Drilling mud – The universal tool of “making hole” to the target depth without a blow-out

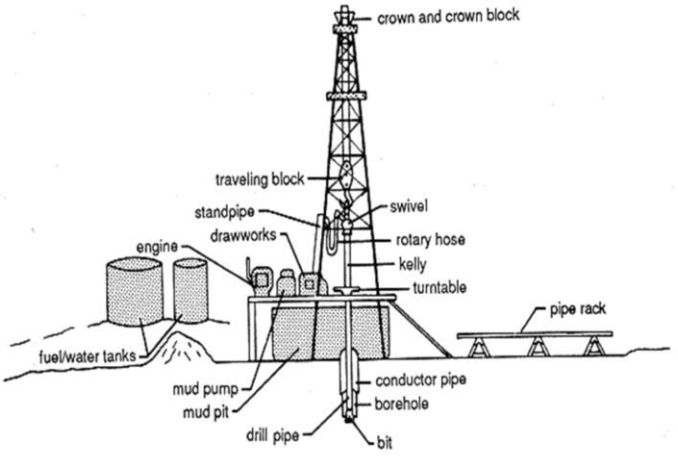
. Diagram illustrating the drilling-fluid (drilling-mud) system and the flow of fluids through the system



The drilling mud process is science and experience; need to prevent a blow-out; high cost clean-up and repair; possible penalties and fines; wide variety of chemicals and materials used

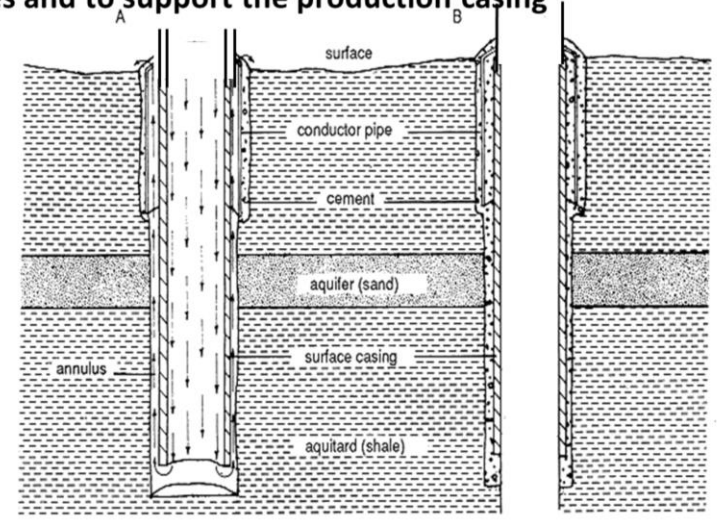
Today BS degree petroleum engineers are starting at $80,000/year – huge demand for new engineers with knowledge of how to drill the new wells and how to produce the wells

A drilling rig with its major components and related equipment.



Always a derrick for drilling since drillers use a long string of pipes connected together; always a pipe rack 18 to 45 feet hollow typically 31 feet

A casing is installed in the surface hole to prevent the contamination of freshwater zones and to support the production casing



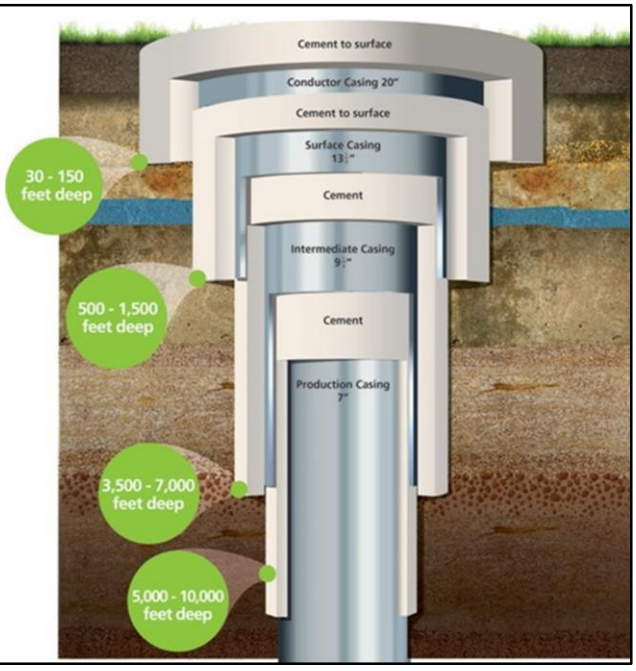
Their intent is to create a concrete barrier in the gap between the metal liner and the hole drilled into the ground/rock

20 inch diameter

13 inch diameter

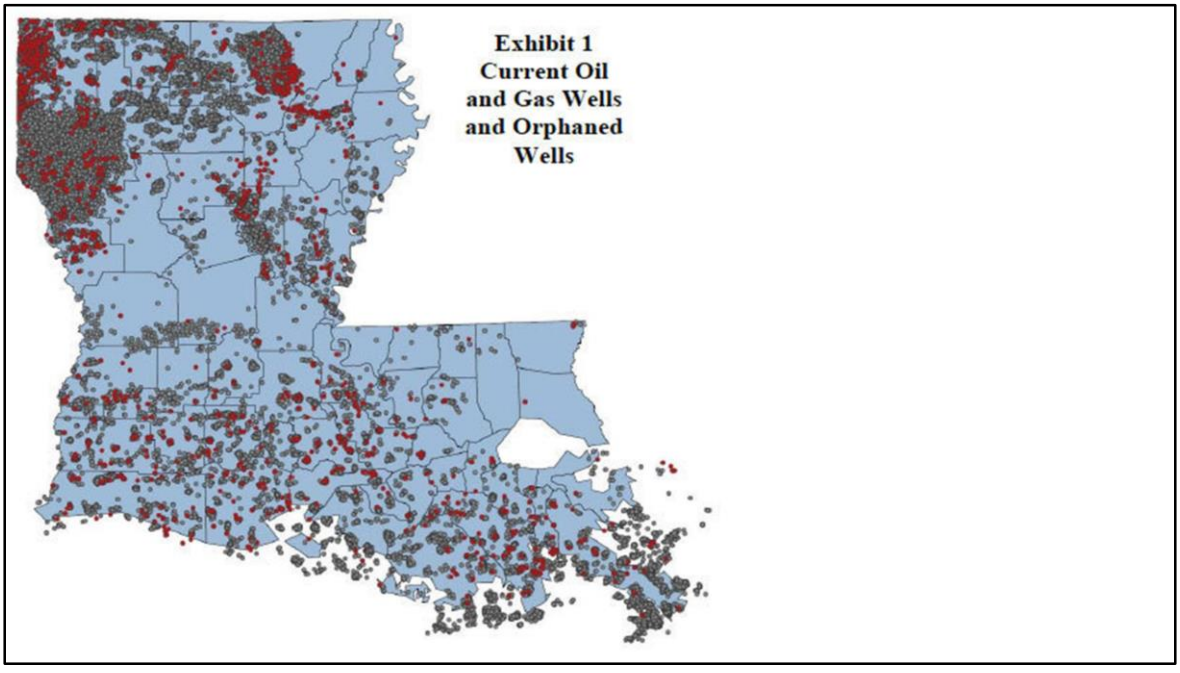
9 inch diameter

7 inch diameter

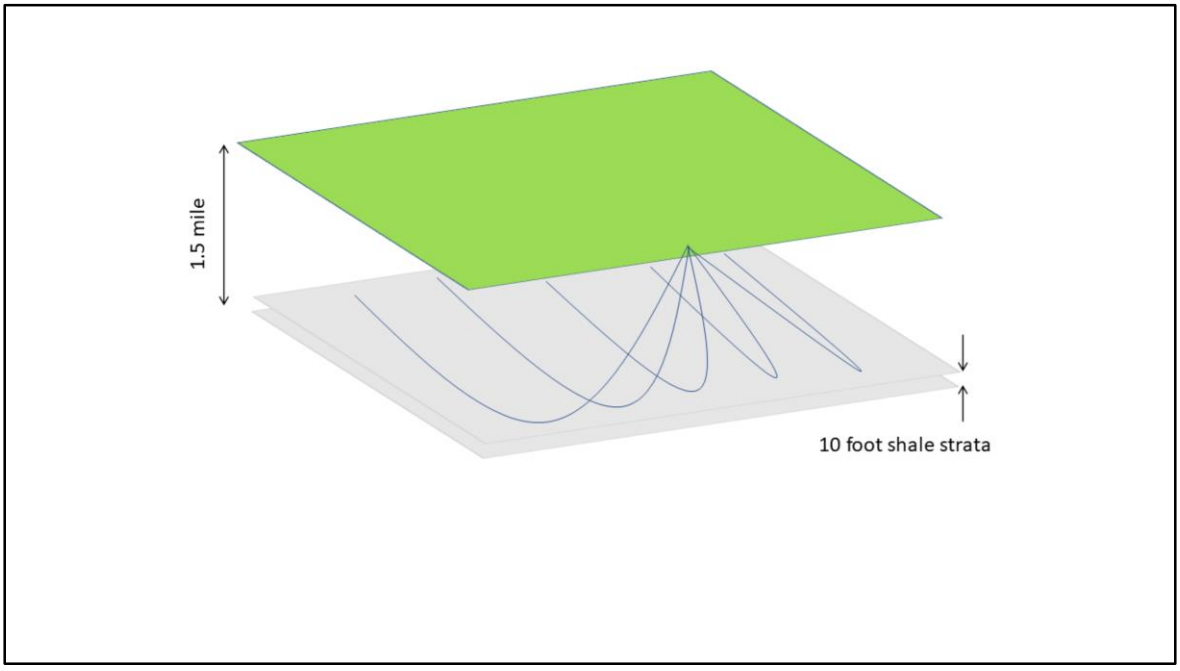


This shows the various pipe diameters for a typical well

Lots and Lots of drilling in the past



This map shows the extent of the drilling of the past; current and abandoned or Orphaned wells



Bakken Shale could have a play at 1.5 mile down and only 10 to 30 feet thick; challenge was how to drill it: cartoon could be a 5 sq mile area

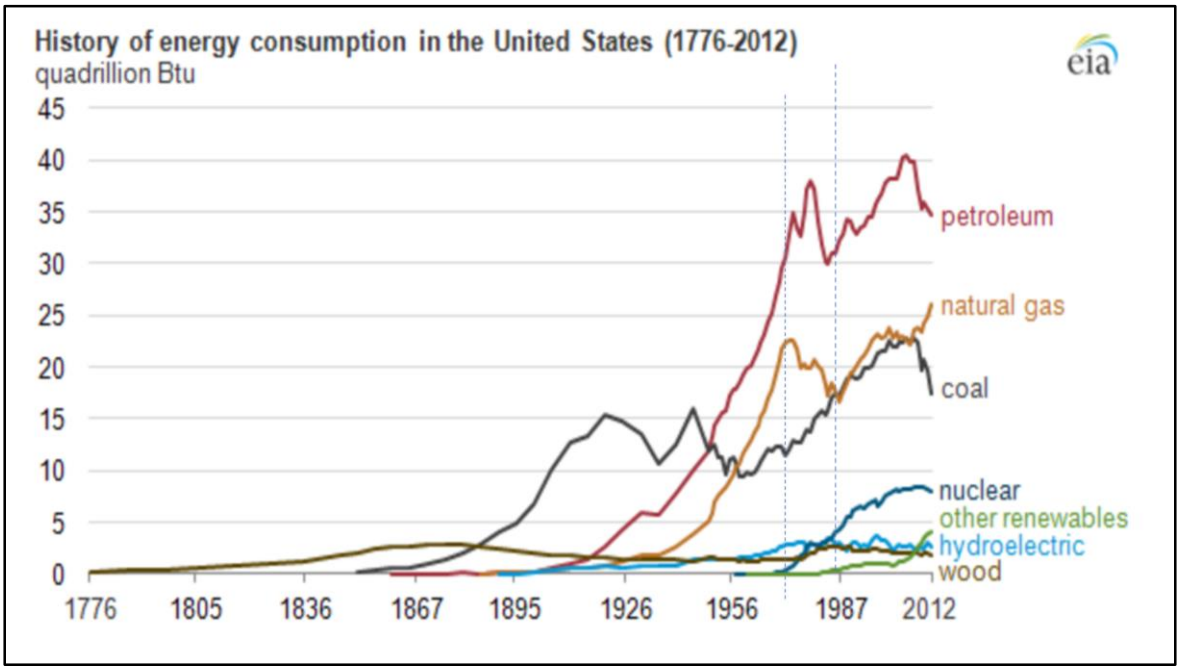
Wisconsin's influence on the oil and gas industry

Phillips Petroleum versus Wisconsin (347 U.S. 672 1954)

1. Natural Gas sold by pipelines under Natural Gas Act
2. Subject to regulation under Federal Power Commission
3. 5 fold increase in rate cases

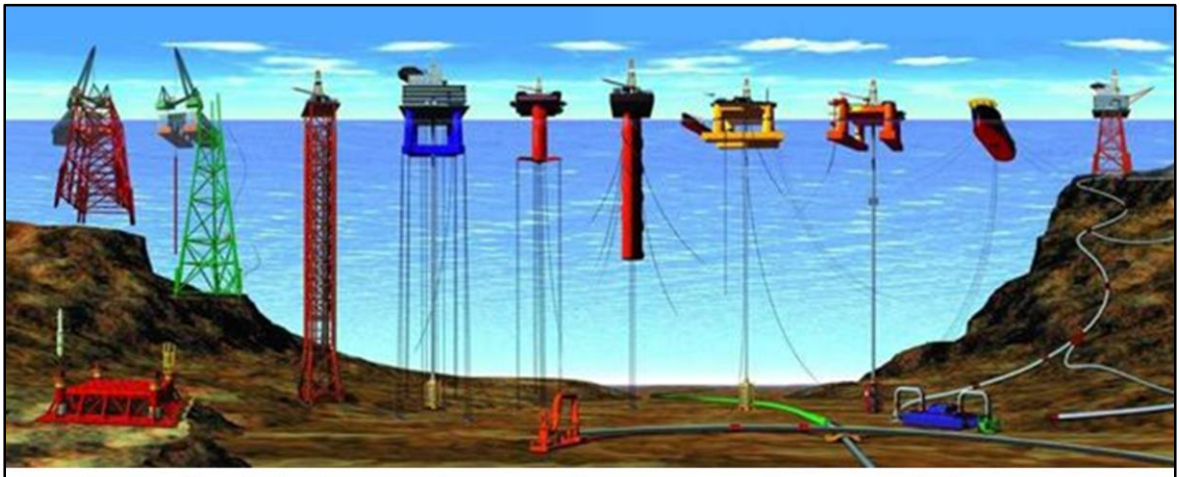
- Cost of service versus value
- Area pricing
- Developed areas under old area costs
- Virtual halt to gas exploration
- Decline in oil exploration in same areas
- Not profitable to drill for oil/gas if regulated profits

Wisconsin filed a court case to try and get the sales of NG to pipelines under FPC regulation –They won!
FPC suddenly had a 500% increase in rate cases
FPC regulated prices based on cost of service not value
To manage the case load FPC declared Area Pricing so a new gas well would only receive the prices set by old well's cost to produce in the same area
Steep decline in oil and gas drilling in these area
Not profitable to drill for oil/gas if profits were to be regulated



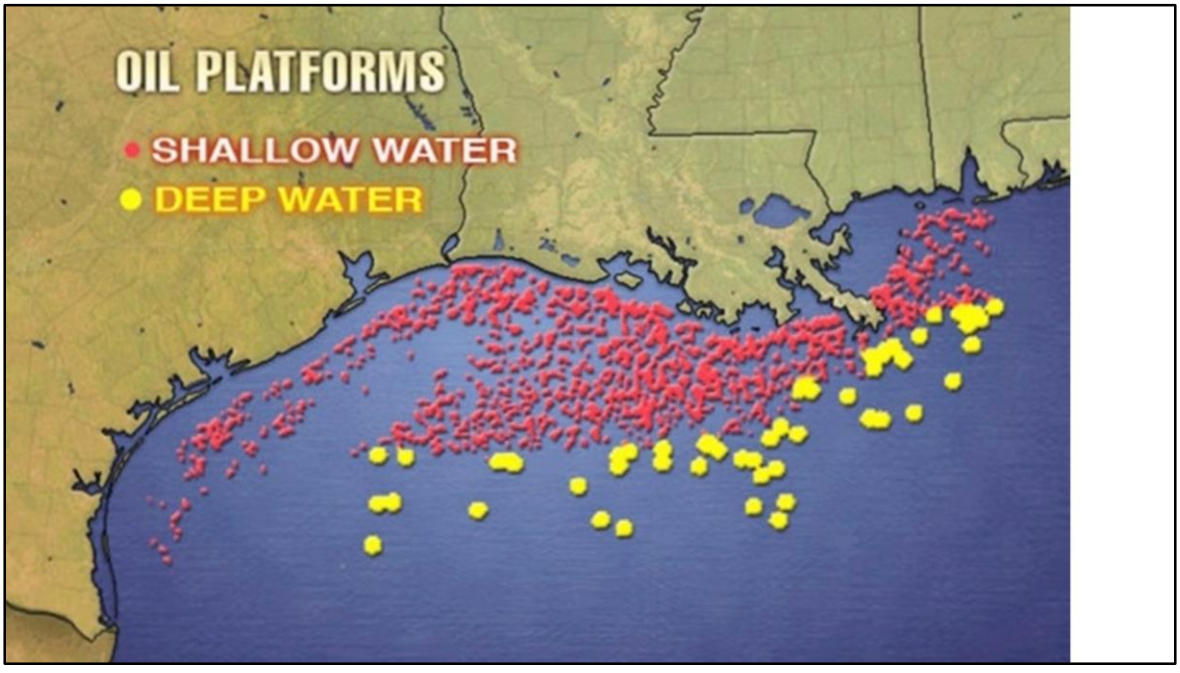
See rapid drop in the discovery and production of oil and gas

Off-shore exploration hastened the development of horizontal drilling



1 and 2 are fixed platforms; 3 is a compliant tower; 6 is a spar platform;
4 and 5 are vertically moored tension leg and mini-tension leg platforms;
7 and 8 are semi-submersibles; 9 is a floating production and offloading facility;
10 sub-sea completion and tie-back to host facility

Off shore drilling provided the learning and development opportunity to drill other than vertical; due to the high cost of an off shore rig, you did not want to move it.



Lots of drilling in the shallow water but much fewer in deep water

Horizontal drilling with hydraulic fracking;

"The new Technology and Petroleum harvesting boon!!"

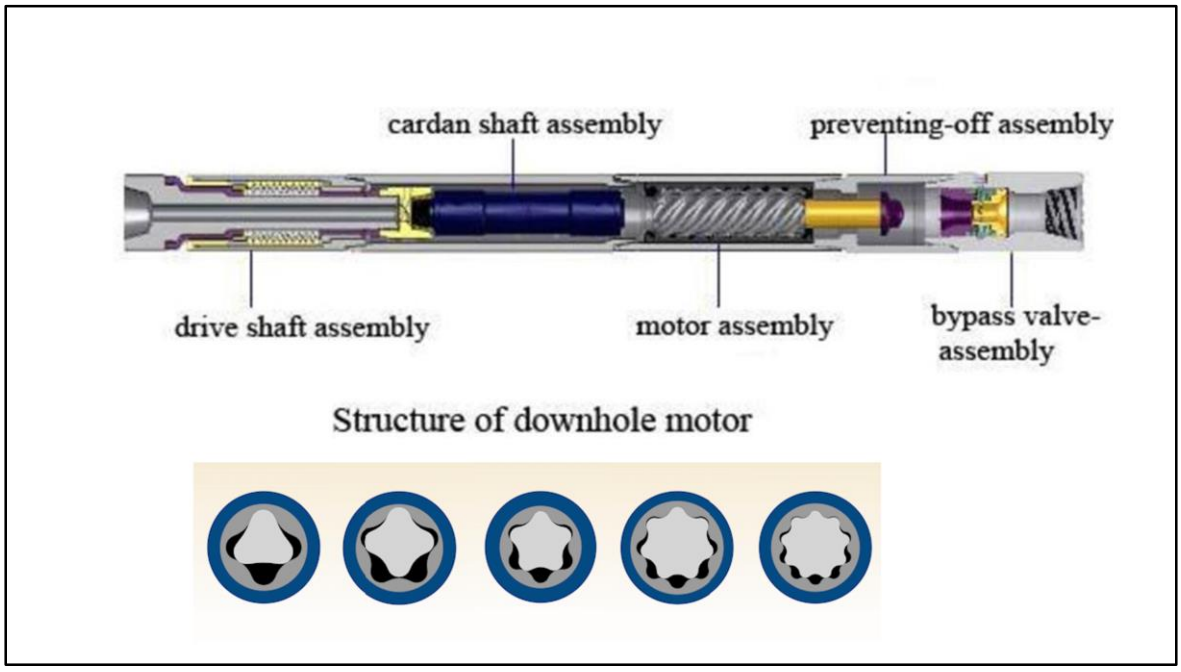
This clip shows the horizontal drilling with fracking raising the likelihood of hitting oil/gas to virtually 100%

Russian and Exxon project in Siberia

Typical tri-cone bit; as the bit rotates the 3 conical shaped rotating pieces rotate; the lobes become a point source of force on the rock; as the entire bit rotates with the string of heavy pipe full of drilling mud on top of it, new surfaces are chipped; the chips mixed with drilling mud and flow up the outside of the pipe to the surface, control of drilling mud density is critical

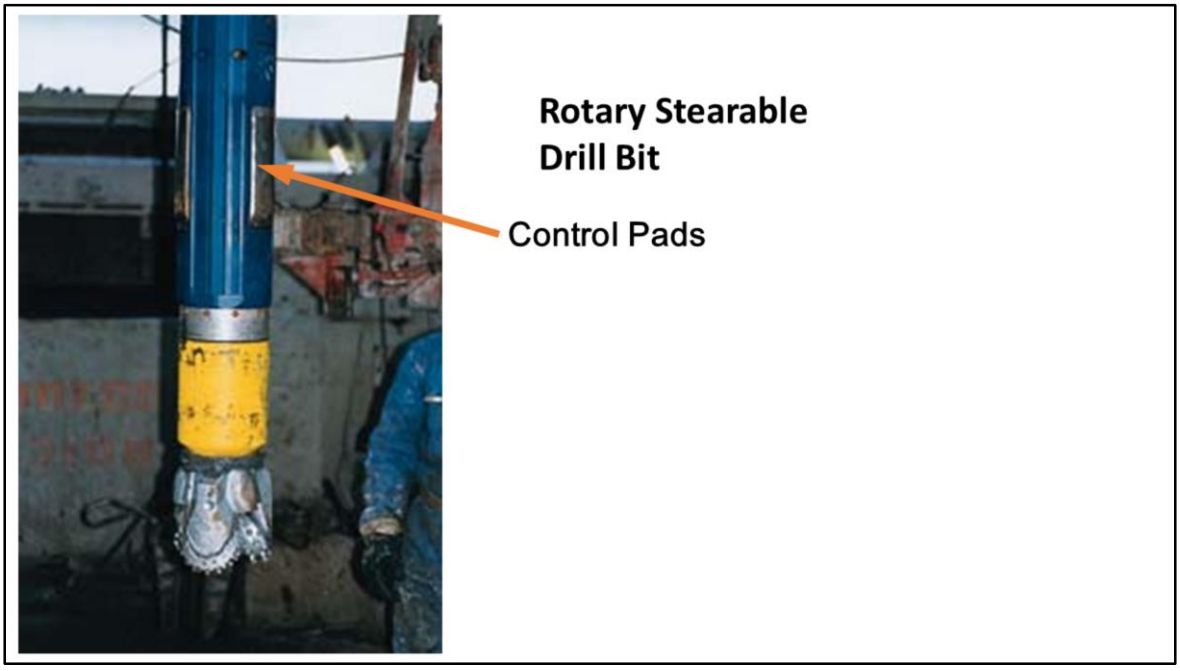
All sizes and styles of bits; from ~$300 to $30,000 depending upon the requirements

The early technology was to use a mud motor attachment on the drill string to create a rotating drill head while the drill string is not rotating, this allowed steering the drill bit to some degree



The motor is driven by the pressure of the drilling mud inside the drill string – fewer lobes higher speed; more lobes more torque

The days of the “Mud Motor” and sliding the casing are being replaced with “Rotary Stearable” using continuous logging via a computer

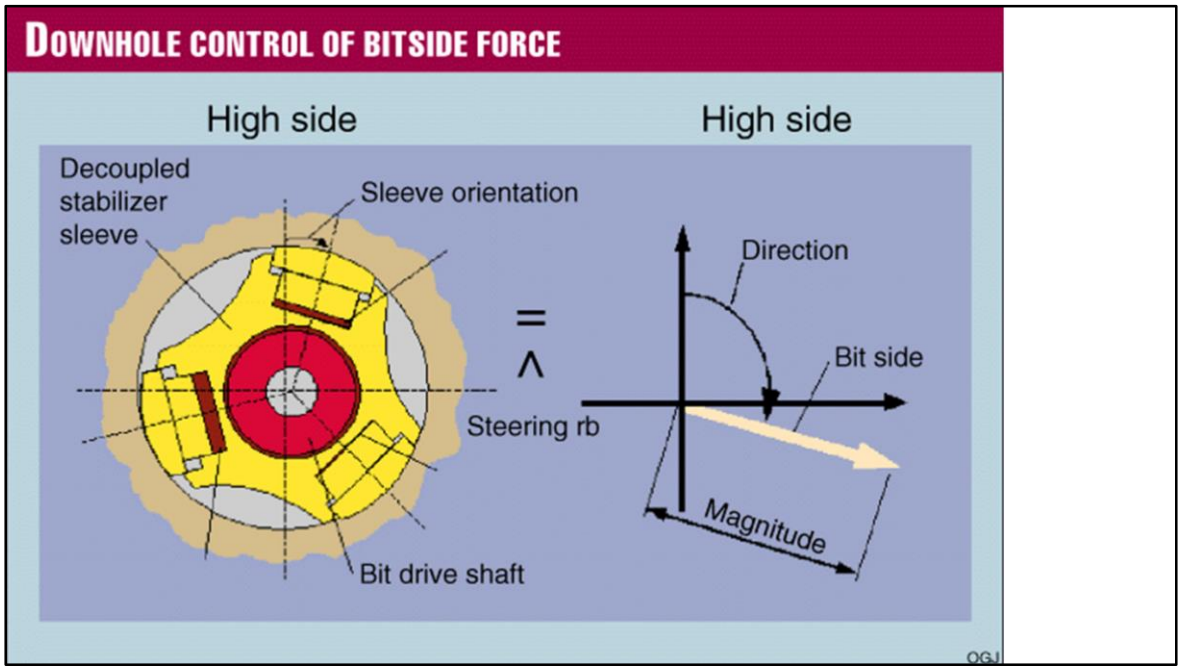


As fracking technology has developed the tools have been developed;

now rotary steerable with continuous logging;

tip of the drill is about 5 feet from steering pads vs being 100 feet behind the tip

Previously used mud motors to drill horizontally; limited due to sliding of casing versus rotation

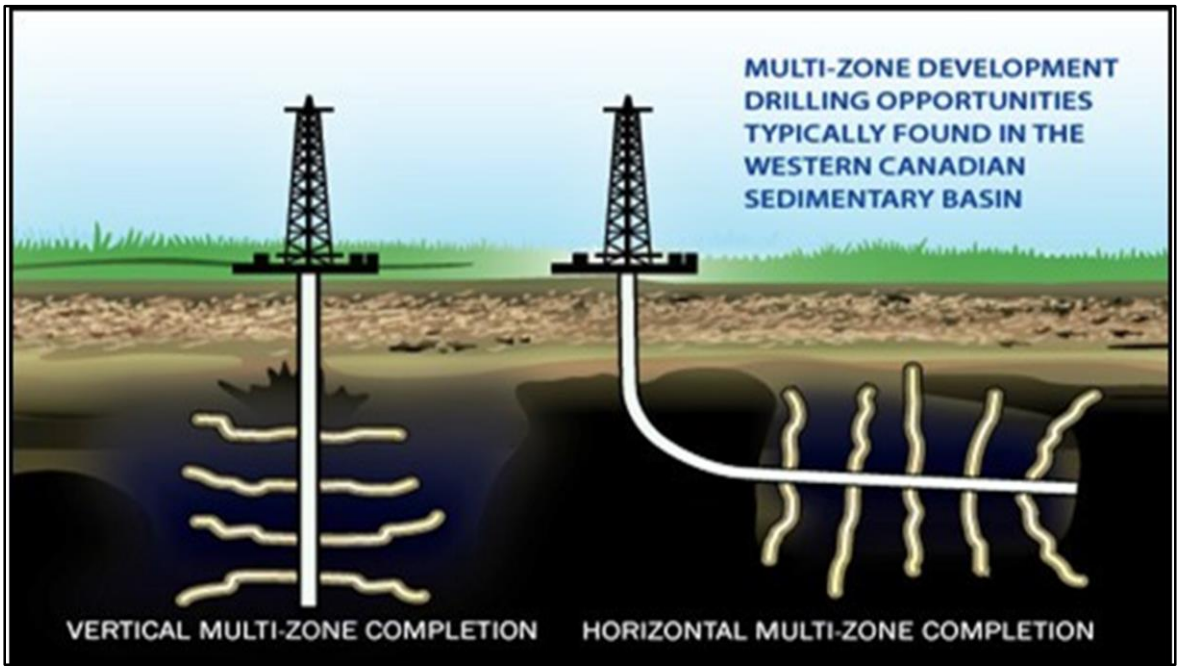


1.The expected build rate in oriented mode should be slightly greater than (typically 1 to 2°/100 ft) that required to guarantee the planned build rate.

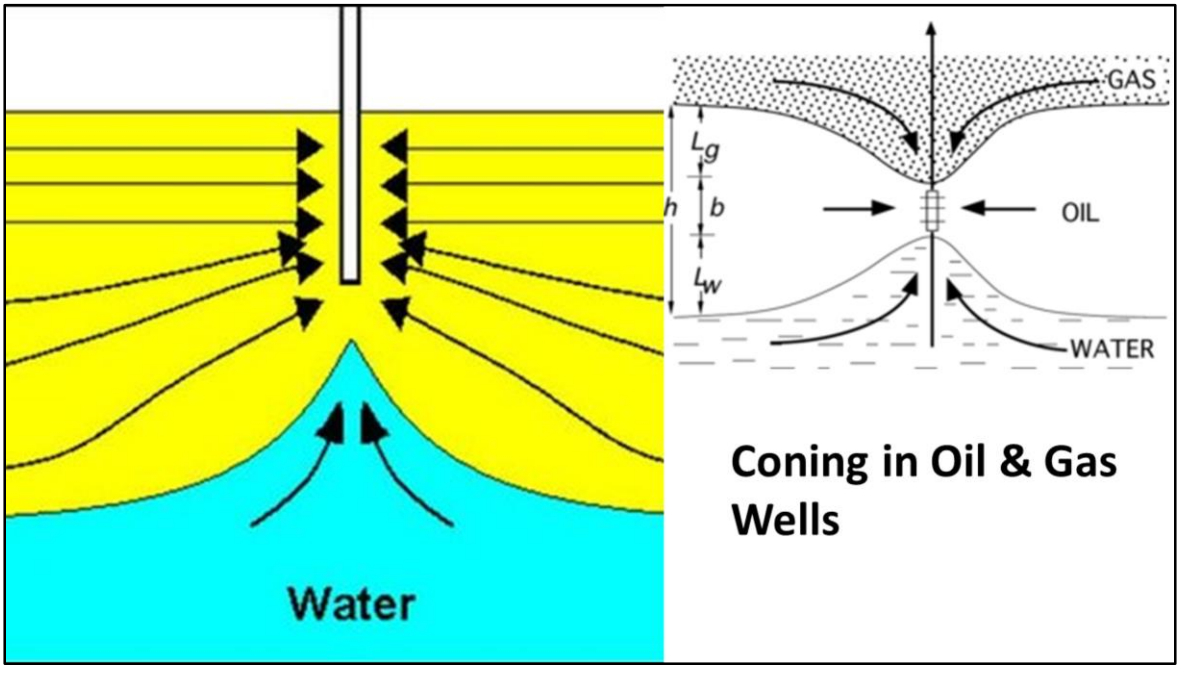
2.The number of stabilizers used should be kept to a minimum to reduce drag in the oriented mode.

3.If the drill string is rotated in a curved section, bending stresses around the bent housing should be checked to ensure that they are less than the endurance limit.

The vast majority of MEDIUM-radius drilling is undertaken in hole sizes of 12¼ in. and less with 8-in. (and less) -diameter motors for build rates of 6 to 15°/100 ft.

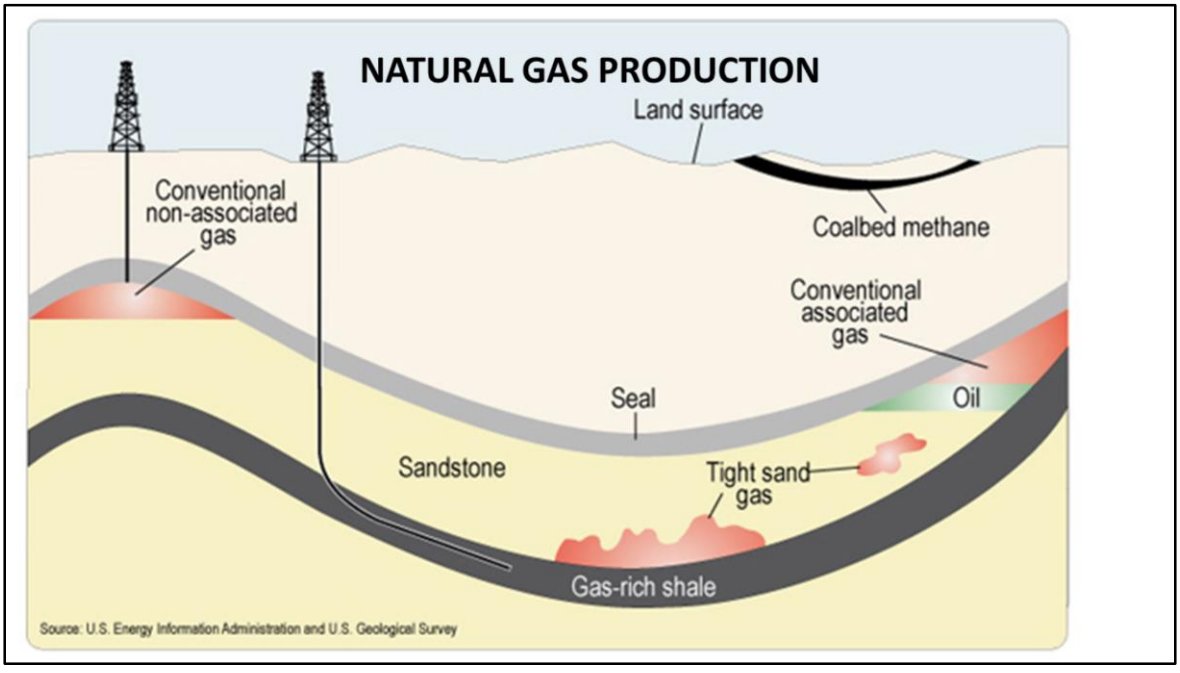


Shows alternates; vertical well and horizontal well; currently the cost of a horizontal well is about 130% of the same length vertical (this is down from 150% about 4 years ago and down from about 200% about 15 years ago; a horizontal well 1.5 mile deep with horizontal drilling of 2 miles could cost about $5,500,000 to $7,000,000



Care must be exercised during the extraction of the oil/gas to prevent coning; once the cone forms very costly to remediate

Oil has the higher value so plan to extract it first



Natural gas is primarily methane CH4; some liquids; sometimes H2S (sour gas); some CO2
Explain drilling for oil and gas; traps; probabilities,

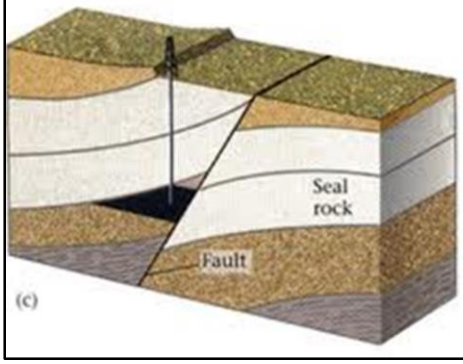
drilling for storage; Drilling company vs oil & gas company philosophy; impact on shale gas & oil;

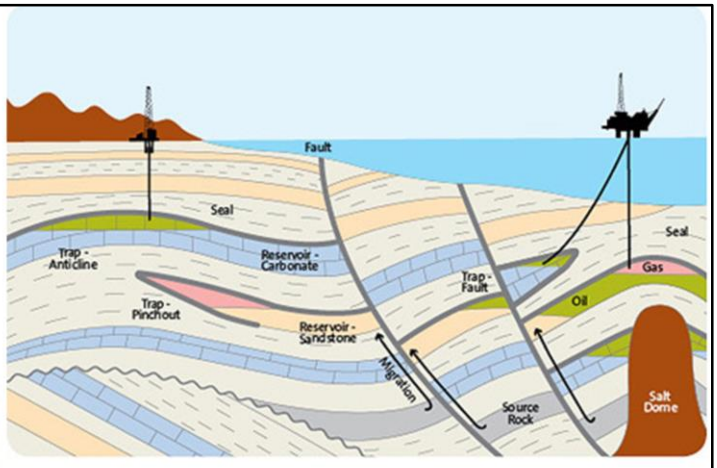
geological data logs BLM records;

geophysical data from echo plotting;

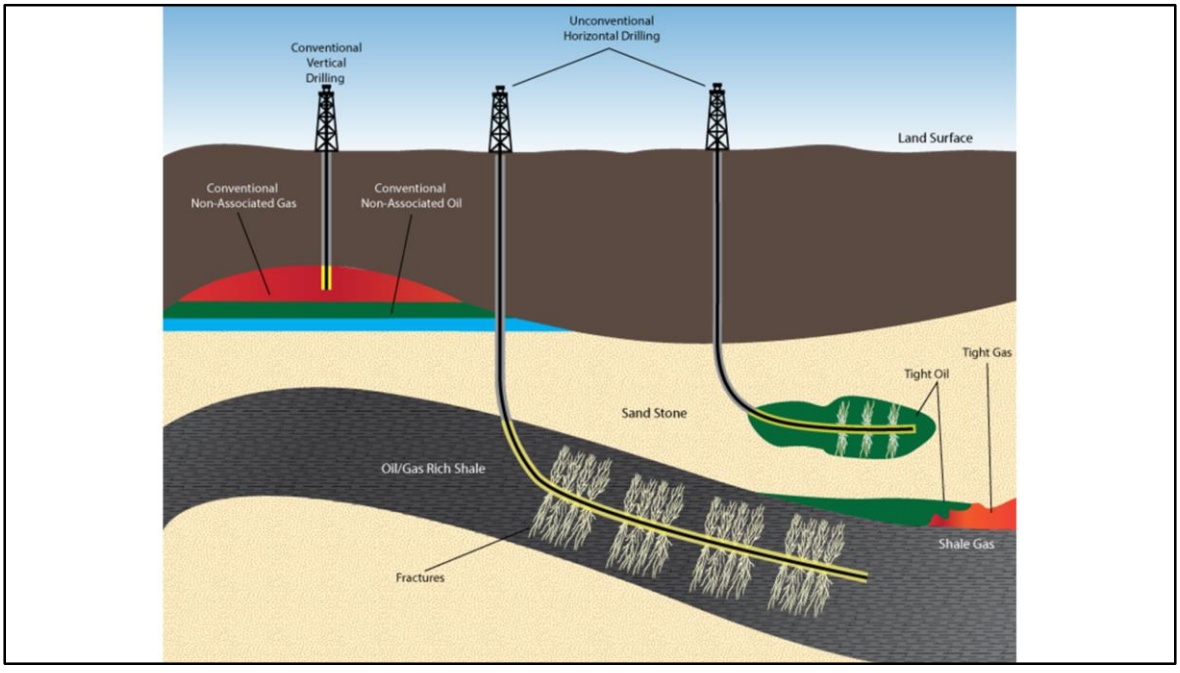
bidding on offshore leases based upon probabilities

Fault lines as traps for oil and gas





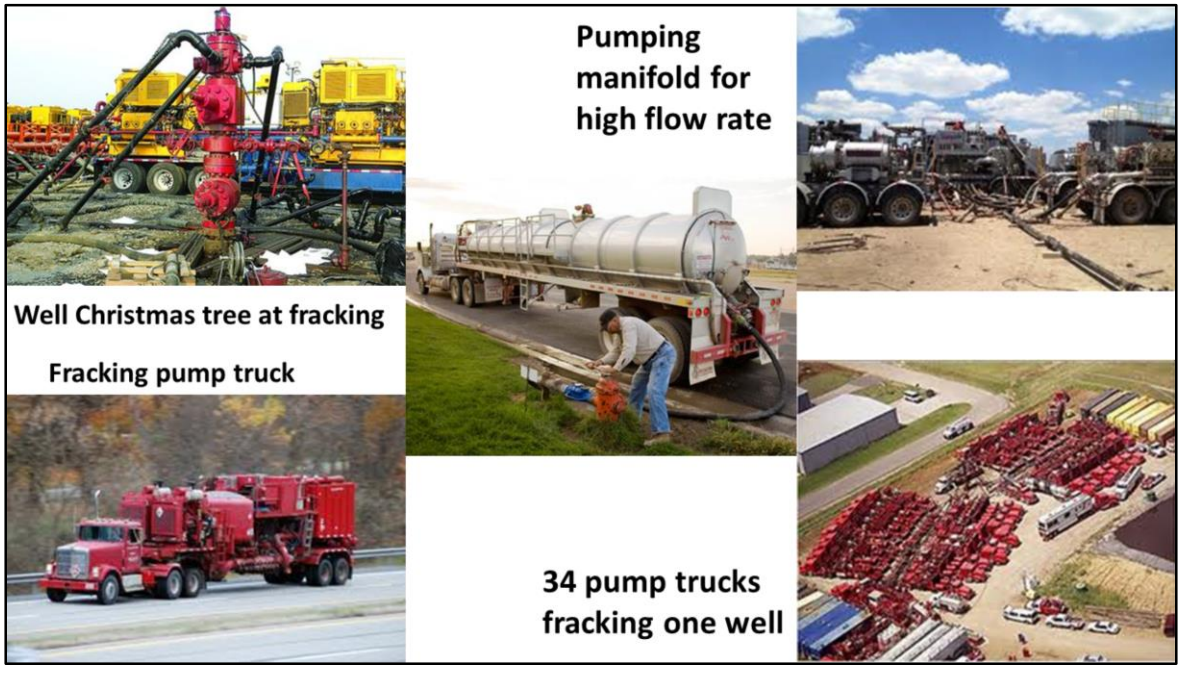
Underground structure is much more complex than cartoon illustrations



This illustrates the typical explanation of the drilling and recovery configuration
Non associated gas /oil was simplest with the water or brine below it
Shale is the biggest play today
Tight oil/gas are still opportunities but permeability is an issue

Fracking fluids and “not-so-secret-ingredients”

Wisconsin’s boon in fracking sand (propant)



Pumper trucks 2000 to 2500 HP
Lots of equipment for mixing and proportioning ingredients
Primary control is the volume and pressure to obtain the degree of increased permeability to be economical

Water use <u>per well</u> can be from 1.5 million to 16 million gallons !! Remember the huge quantity of water

Iron Truck Equipment

High pressure piping to get pressure and flow up to needed quantity. Not a closed system but a leaky system with high viscosity fluid to create the internal pressure

Slurry Blender

High-Pressure Pump (2000 HP; 15,000 psi; 20bpm)

Almost Secret ingredients added here!!

Chemical Additive Unit

Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics

Typical chemical additives used in Frac water

Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring

The thickeners and gums are needed to keep the sand suspended in the liquids and moving into the cracks of the rock

Federal Regulations ***Exempting*** Oil & Gas Exploration and Production (2005)

- Federal Clean Water Act
- Safe Drinking Water Act
- Federal Clean Air Act
- Super Fund Law
- Resource Recovery and Conservation Act
- Toxic Release Inventory
  - Emergency Planning and Community Right-to-Know Act

Dick Cheney had been president of Haliburton; major player in the oil and gas industry; obtained this Exemption

The "Halliburton Loophole". Halliburton first patented fracking in the 1940s, and is the world's largest fracking services provider. With the help of former Halliburton CEO, Dick Cheney, the United States 2005 Energy Bill passed with language that exempted fracking operations from the regulations of the Safe Drinking Water Act, and exempted the concoction of chemicals used for fracking from pollutant status under an amendment to the Clean Water Act and Clean Air Act.

The EIA has at least one publication out that attempts to address some of the issues with drinking water

The concern here is the missing data not included due to the claim of corporate confidential information

While there is a good start to answering many questions the missing data precludes making many conclusions.

The various parties appear to have taken on an adversarial position to avoid potential law suits and liability rather than trying to find the best way to harvest this US resource with the least environmental impact

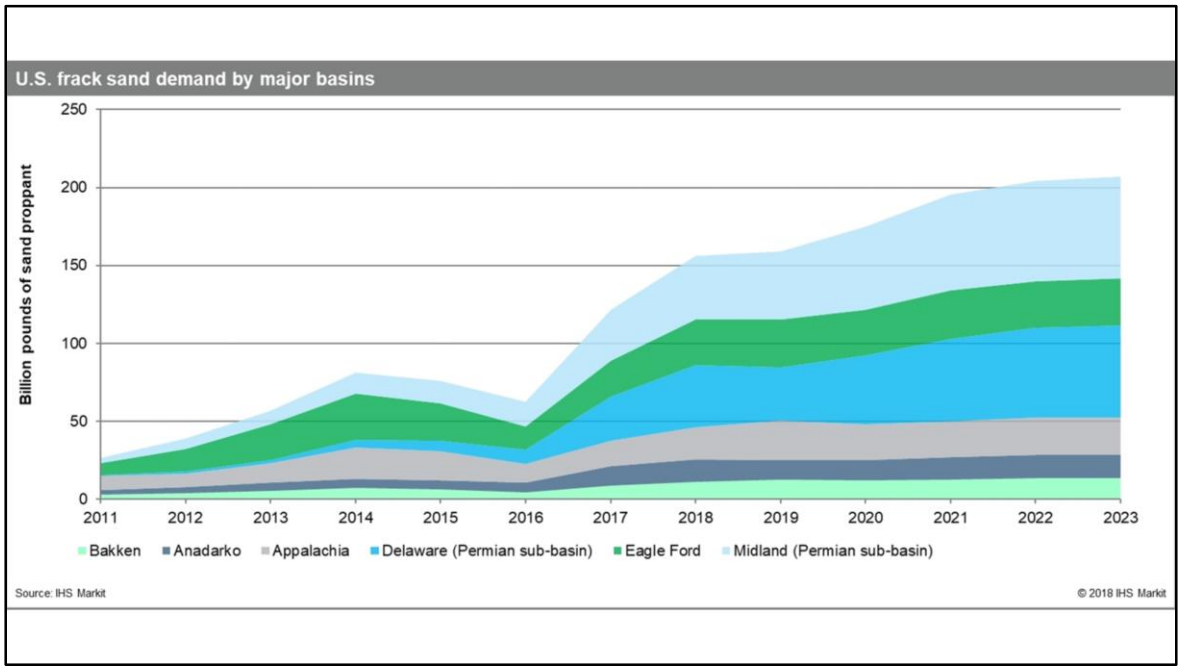
Fracking Sand or Propant Wisconsin's Bonus

Fracking sand operation Wisconsin Trempealeau County

Carbo Prop

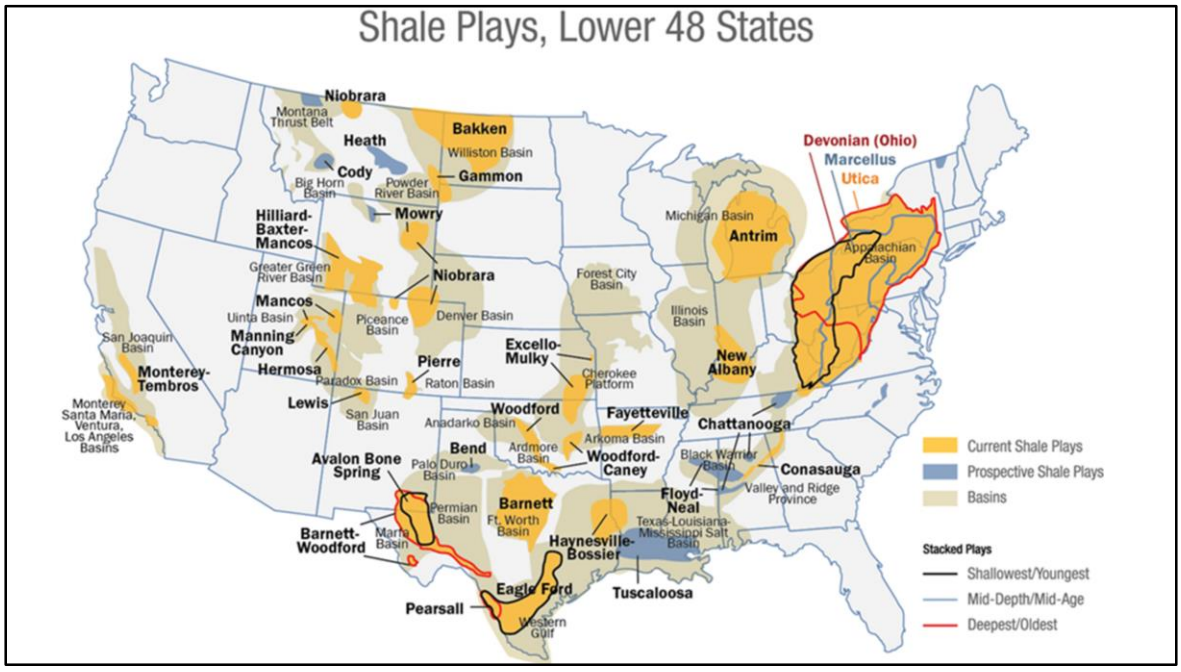

berm
8
6
5
7
9
1
10
4
3
2
Stormwater runoff pond
Process-water pond

Frac sand various sizes.
0.1 millimeter in diameter to over 2 millimeters in diameter.
frac sand used in the oil and gas industry is between 0.4 and 0.8 millimeters

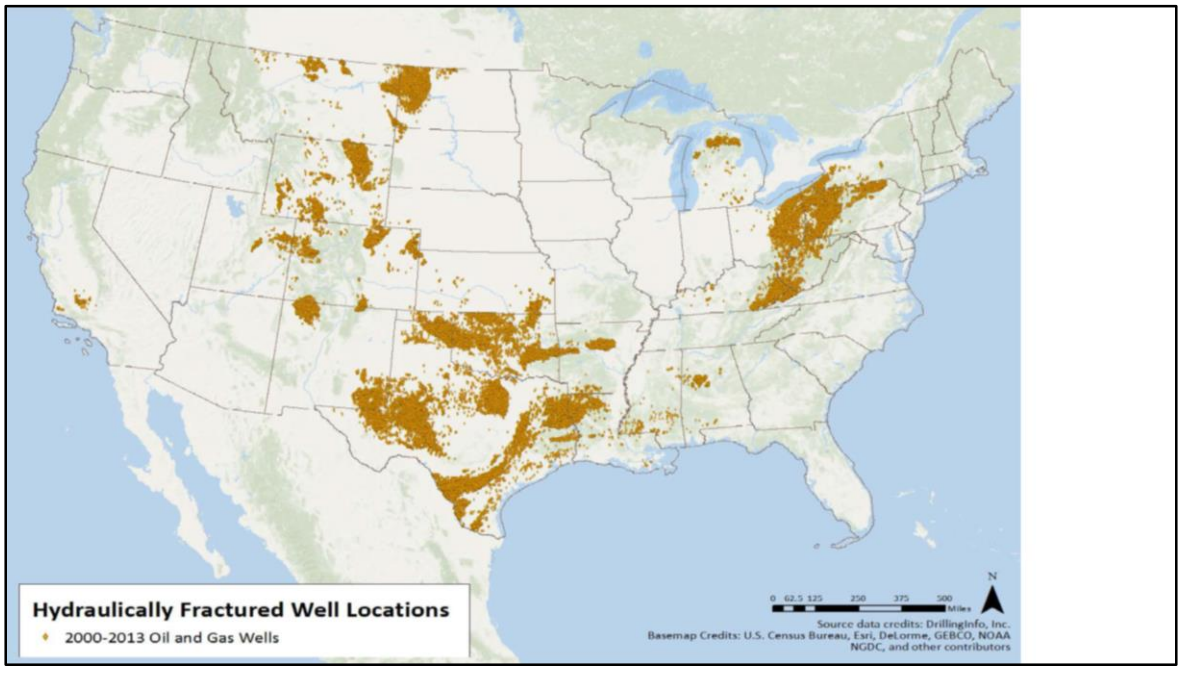


Market looks good for supplying frack sand

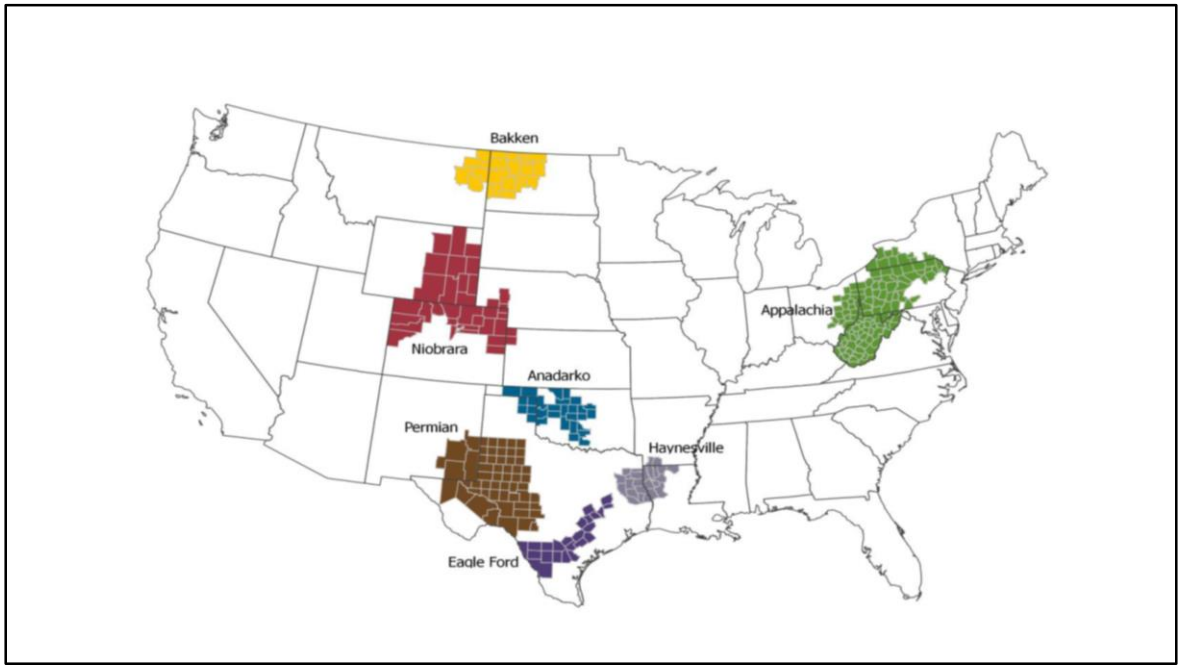
USA's Major Activity in lower 48



Yellow current plays
Blue prospective plays
Gray basins
Stacked-- black youngest; red deepest/oldest
How to balance the interests of the oil/gas company; produce our natural resource; and maintain an environmental benefit?



1990s George P Mitchell considered to be father of modern hydraulic fracking; combined horizontal drilling with hydraulic fracking
About 1 million in USA
1.5 million outside USA



Drilling Productivity Report November 2018 For KEY tight oil and shale gas regions

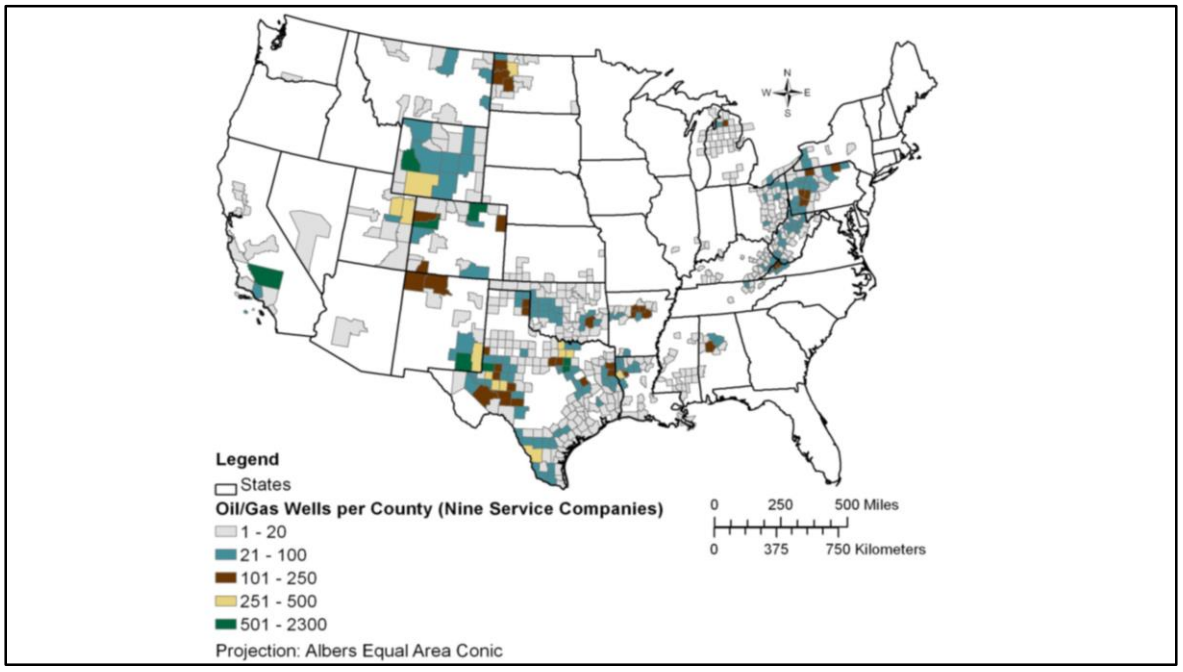
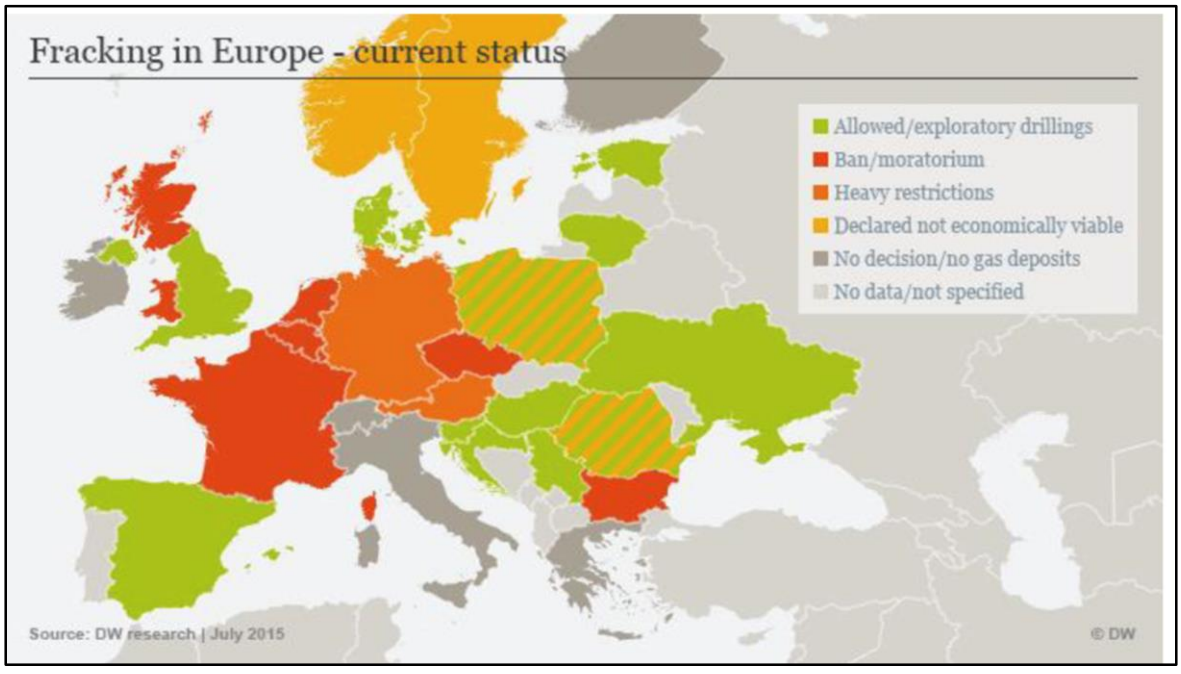
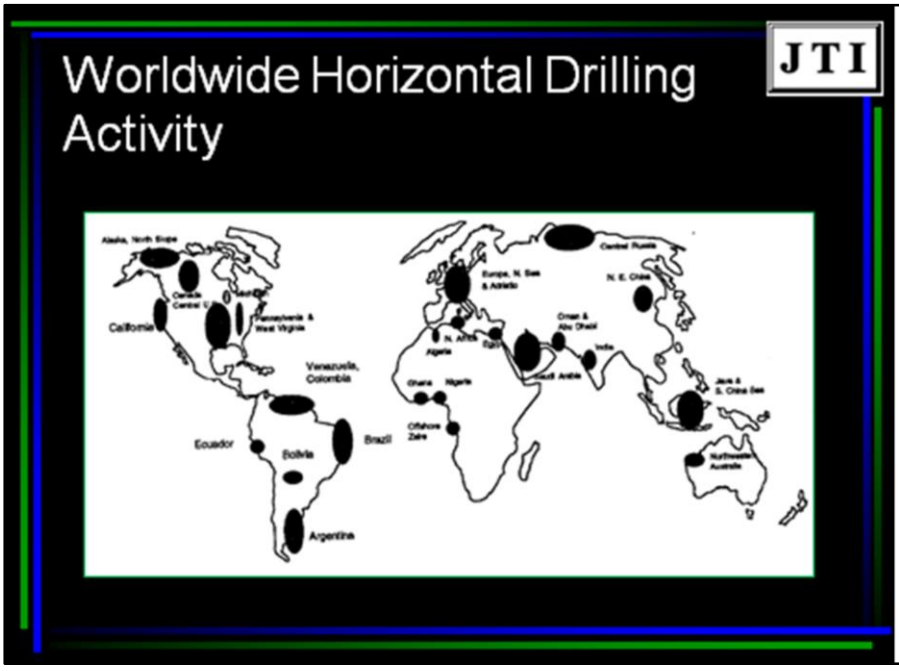


Figure 10. Locations of oil and gas production wells hydraulically fractured between September 2009 and October 2010. The information request to service companies (September 2010) resulted in county-scale locations for 24,925 wells. The service company wells represented in this map include only 24,879 wells because the EPA did not receive locational information for 46 of the 24,925 reported wells. (ESRI, 2010a, b; US EPA, 2011a)
Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report December 2012

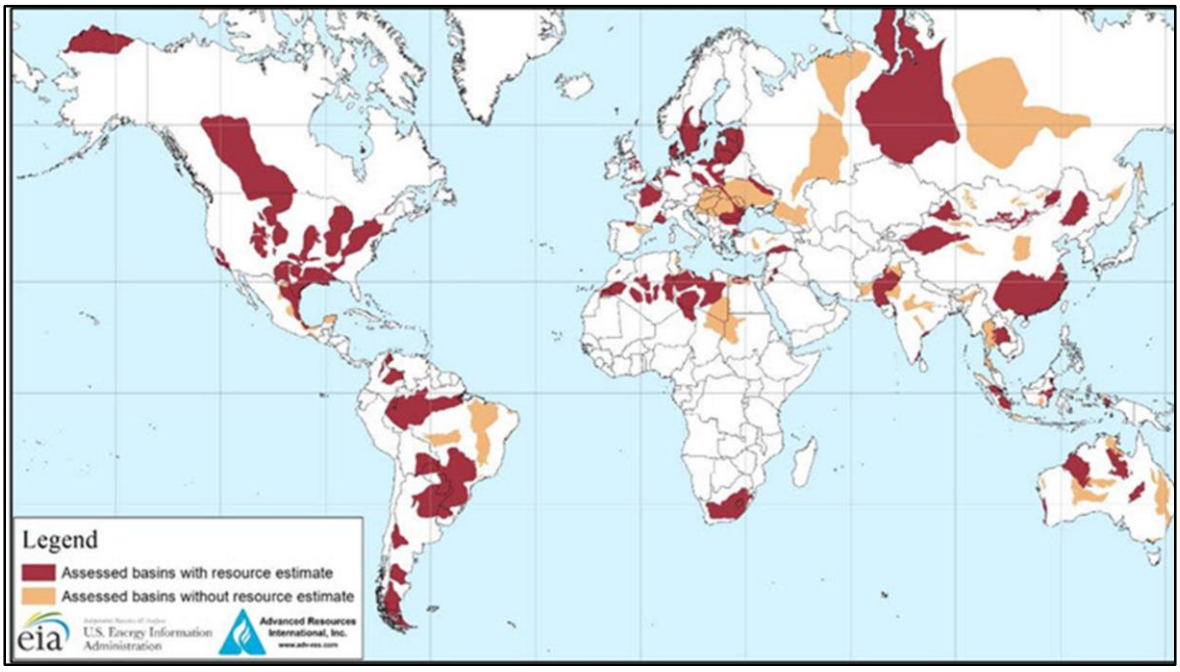
Horizontal drilling with fracking is going around the world and growing



Some countries have banned or established a moratorium

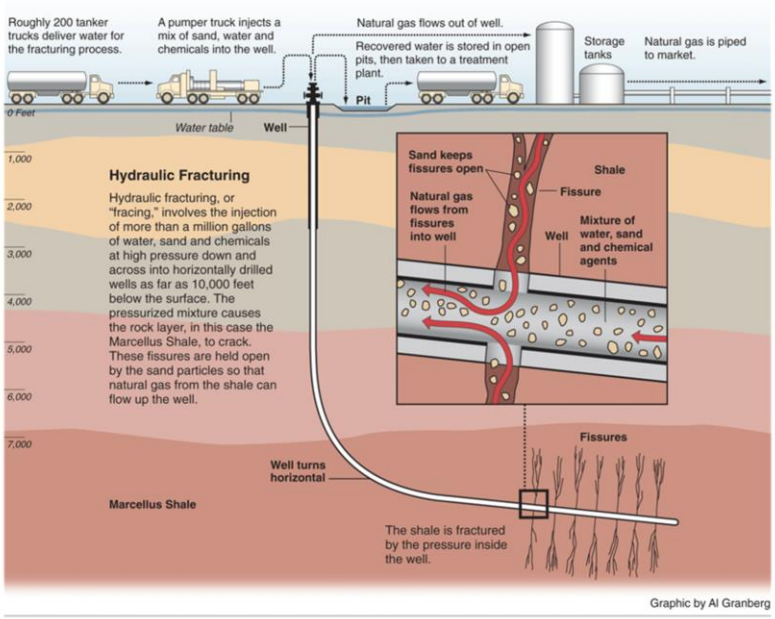


By 2012 about 2.5 million fracking jobs world wide but over a million in USA



Lots of opportunity for oil/gas; Red areas indicate that some sort of estimate has been made of the total recoverable oil/gas resource

Tan areas are known basins of potential oil/gas resources but no estimate



Hydraulic fracturing- propagation of fractures in a rock layer, via pressurized fluid.. first economical play, via horizontal, slickwater fracking, 1998 in a Barnett Shale in Texas.

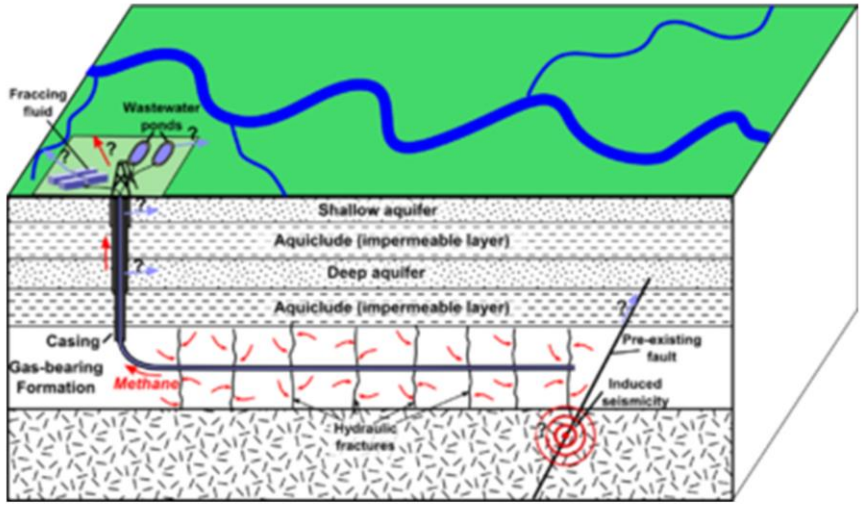
Proponents- economic benefits from formerly inaccessible hydrocarbons

Opponents- potential environmental & health impacts; contamination of ground water, risks to air quality, migration of gases and chemicals to the surface, surface contamination from spills and flowback

Due to shale's high porosity and low permeability, technology research, development and demonstration were necessary before hydraulic fracturing could be commercially applied to shale gas deposits. In the 1970s the United States government initiated the Eastern Gas Shales Project, a set of dozens of public-private hydro-fracturing pilot demonstration projects. During the same period, the Gas Research Institute,, received approval for research and funding from the Federal Energy Regulatory Commission. In 1977, the Department of Energy pioneered massive hydraulic fracturing in tight sandstone formations; United effort for benefit to USA

Fracturing equipment operates over a range of pressures and injection rates, and can reach up to 15,000 psi and 9.4 cu ft/s) (100 barrels per minute).

Schematic depiction of hydraulic fracturing for shale gas, showing potential environmental effects.

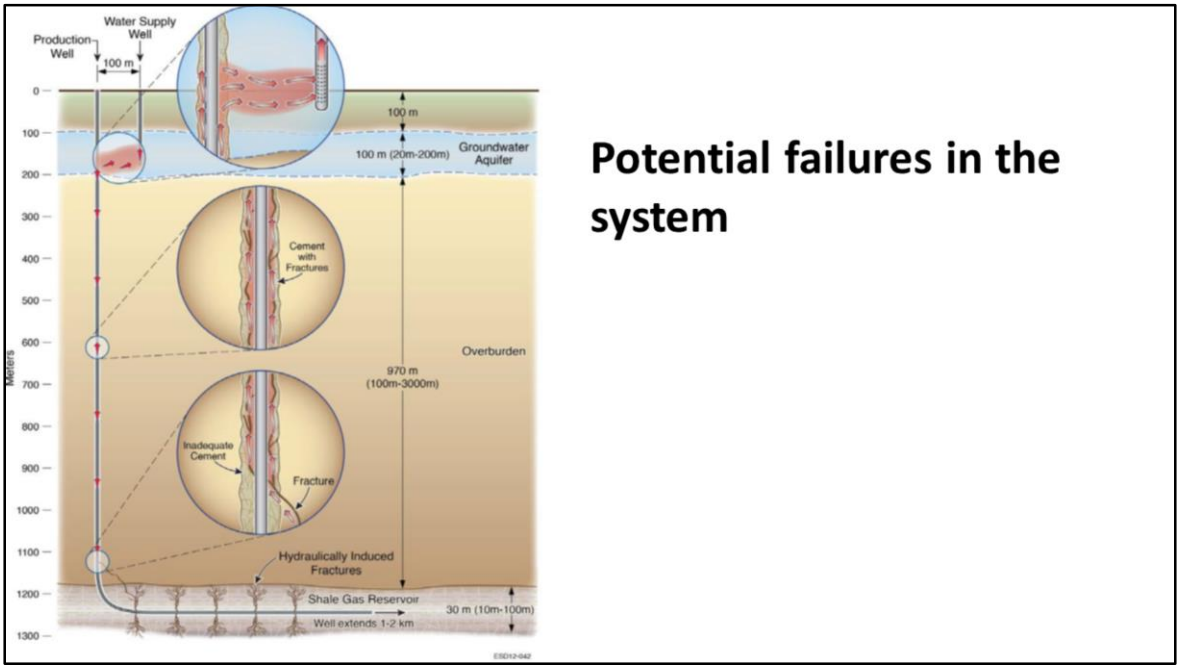


Hydraulic fracturing has raised environmental concerns and is challenging the adequacy of existing regulatory regimes. These concerns have included ground water contamination, risks to air quality, migration of gases and hydraulic fracturing chemicals to the surface, mishandling of waste, and the health effects of all these.

A University of Texas study listed water contamination and consumption, blowouts, explosions, spill management, atmospheric emissions, and health effects as associated problems. The study described the environmental impact of each part of the hydraulic fracturing process, which included:

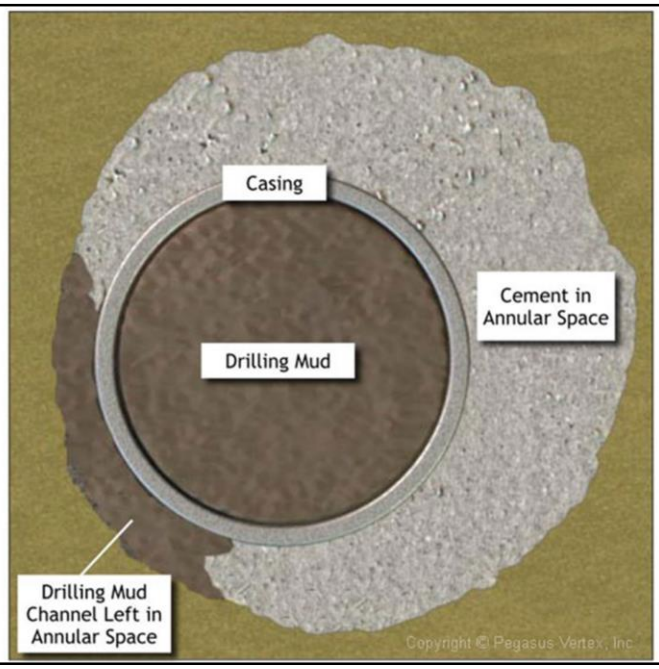
- **Drill pad construction and operation**
- **Construction, integrity, and performance of the wellbores**
- **Injection of the fluid once it is underground (which proponents consider the actual "fracking")**
- **Flowback of the fluid back towards the surface**
- **Blowouts, often unreported, which spew hydraulic fracturing fluid and other byproducts across surrounding area**
- **Integrity of other pipelines involved**
- **Disposal of the flowback, including waste water and other waste products**

All *but* the injection stage were reported to be sources of contamination. Because hydraulic fracturing originated in the United States, its history is more extensive there than in other regions.



Potential failures in the system

What's the base line? How has your oil well changed the base line quantities of water well contaminates?



This cross section from a well shows a potential leak where the cementing effort was less than satisfactory ; weak seal due to leakage of the mud plug if pressure increases or water intrusion occurs

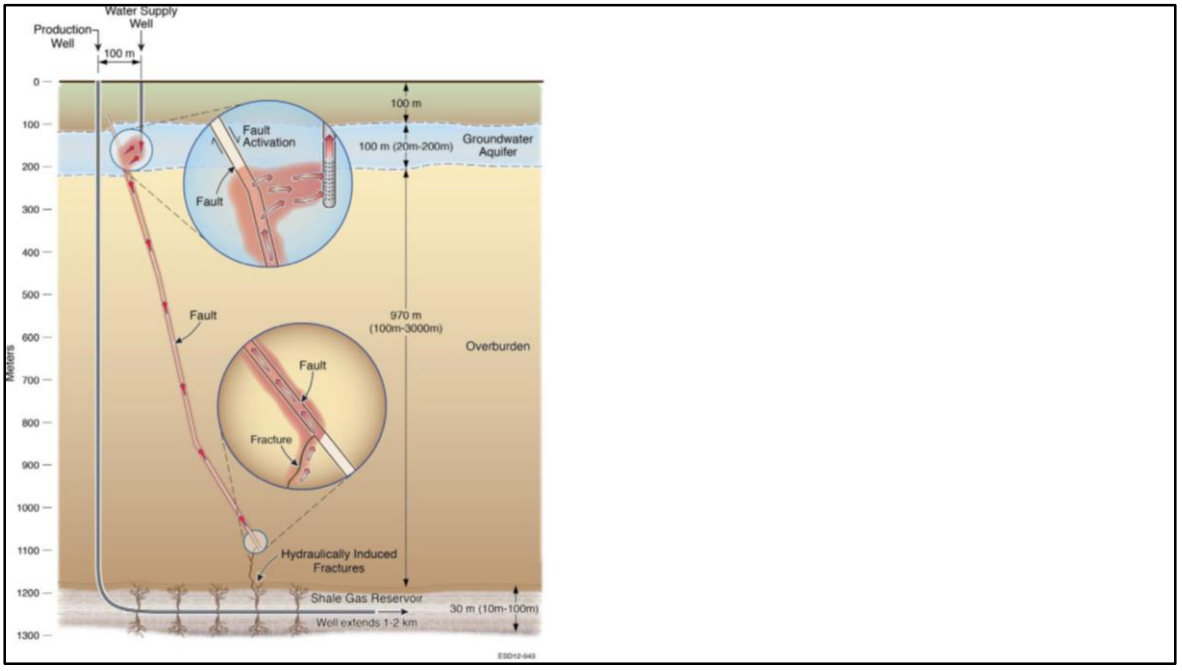
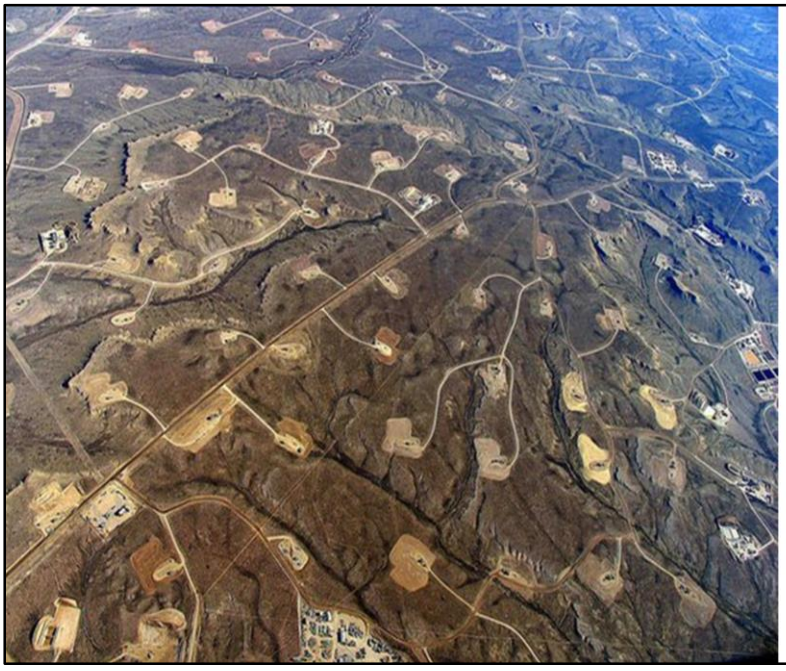
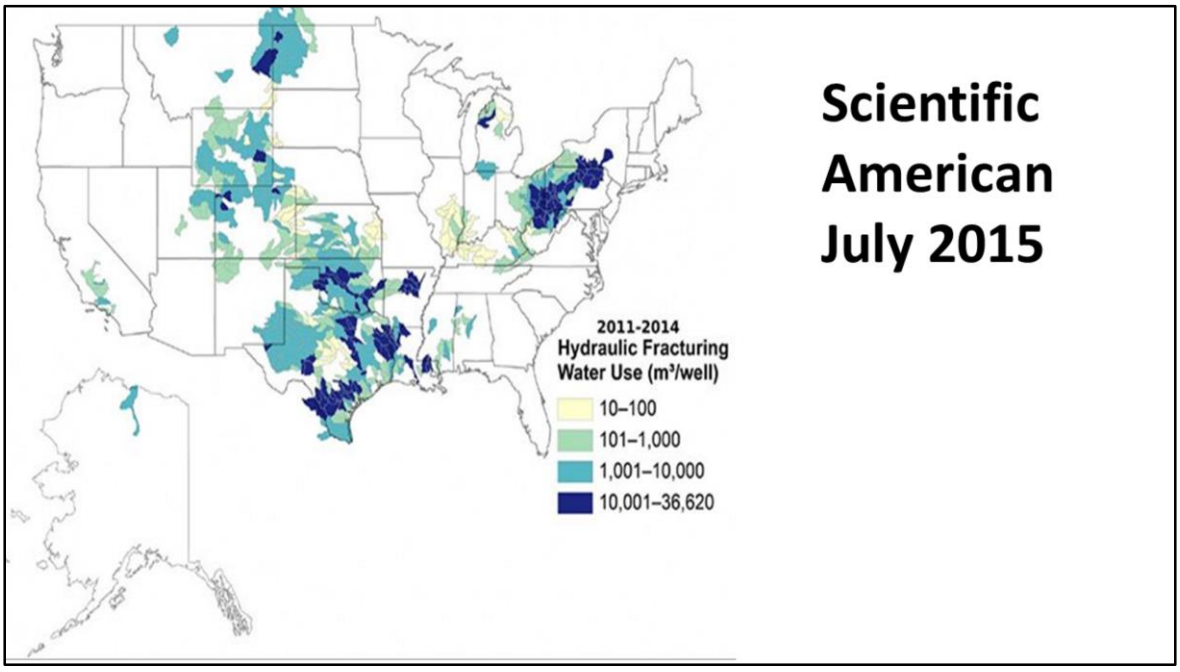


Figure 17. Scenario C of the subsurface migration modeling project. This hypothetical scenario simulates upward migration of hydrocarbons and other contaminants through sealed/dormant fractures and faults activated by the hydraulic fracturing operation.

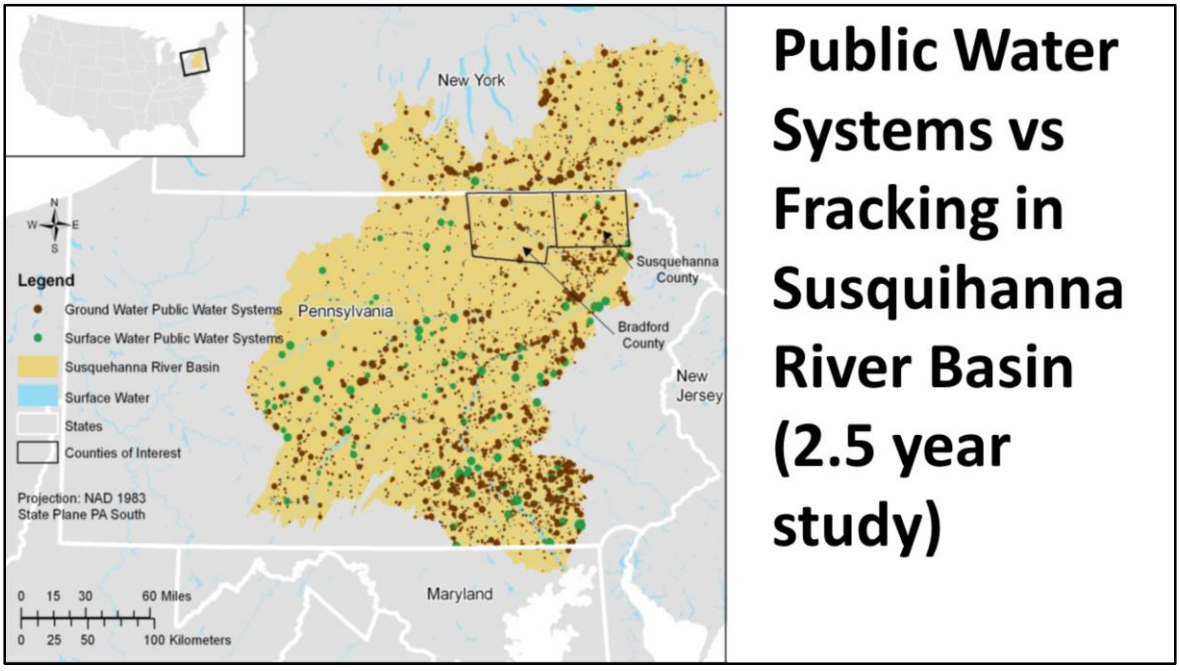


Oil and natural gas fracking, uses more than 28 times the water it did 15 years ago, up to 9.6 million gallons of water per well

U.S. Geological Survey study published by the American Geophysical Union, the first national-scale analysis and map of water use from hydraulic fracturing operations.

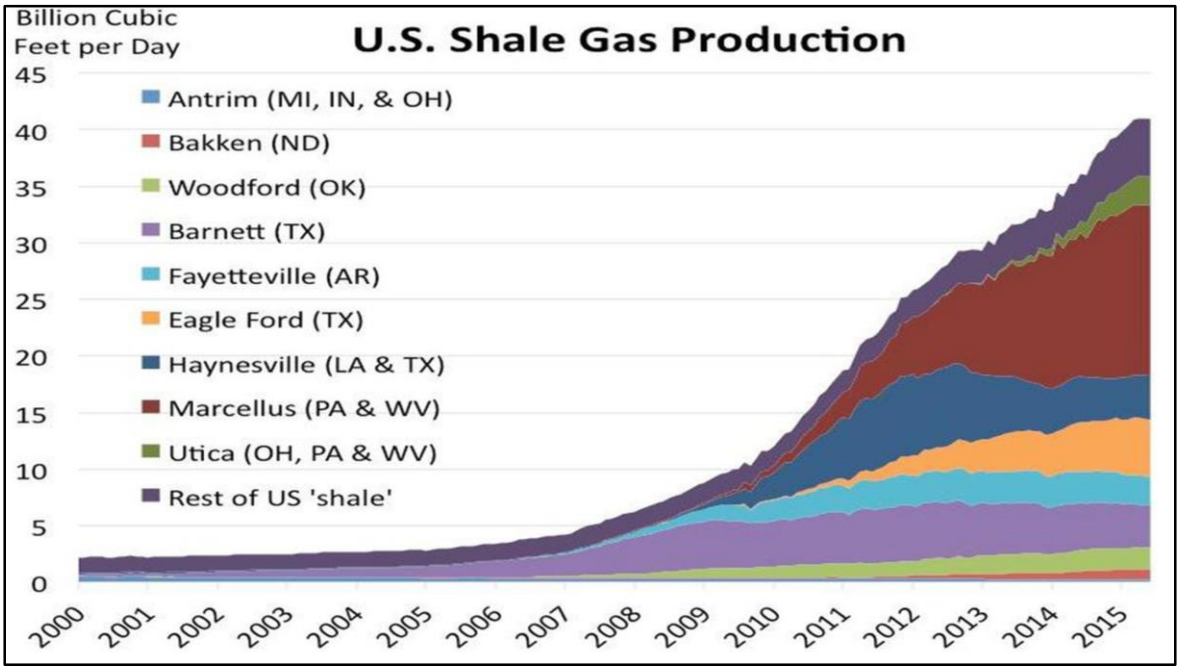


Fracking, which was banned in New York this week because of water pollution and climate concerns, injects large quantities of sand, water and chemicals into the ground at high pressure to release trapped oil and natural gas. The process has been found to leak large amounts of methane, a potent greenhouse gas, and the resulting fossil fuels are the primary cause of climate change.



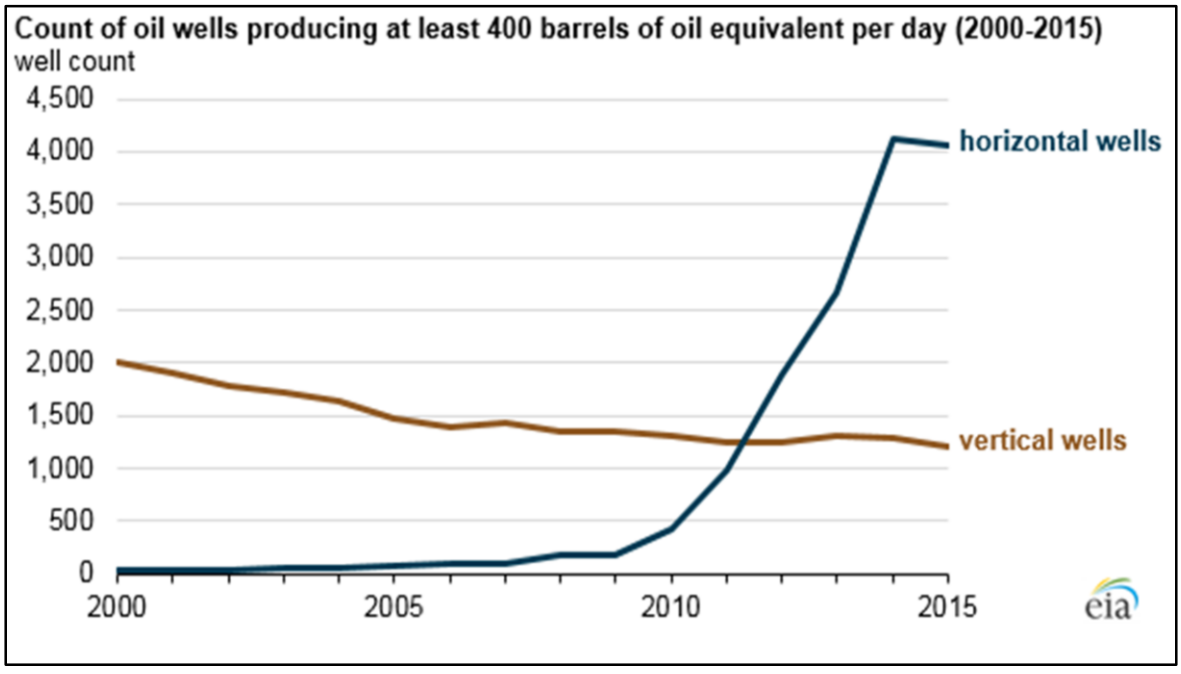
The legend symbol size for public water systems is proportional to the number of people served by the systems. the smallest circle water systems **25 to 100 people and largest circle systems over 100,000 people.**

The Susquehanna River Basin Commission reports that the **oil/gas industry consumed over 1.6 billion gallons of water for well drilling and hydraulic fracturing in the entire SRB from(2.5 yr)** or 1.7 MGD. The 65% direct surface water withdrawals, from PWS 35%) The **average total volume of fluid used per well was 4.2 million gallons,** 90% fresh water The **average recovery of fluids was reported to be 8% to 12% of the injected volume within the first 30 days** Water use Bradford and Susquehanna Counties **2 and 9 million gallons per well**

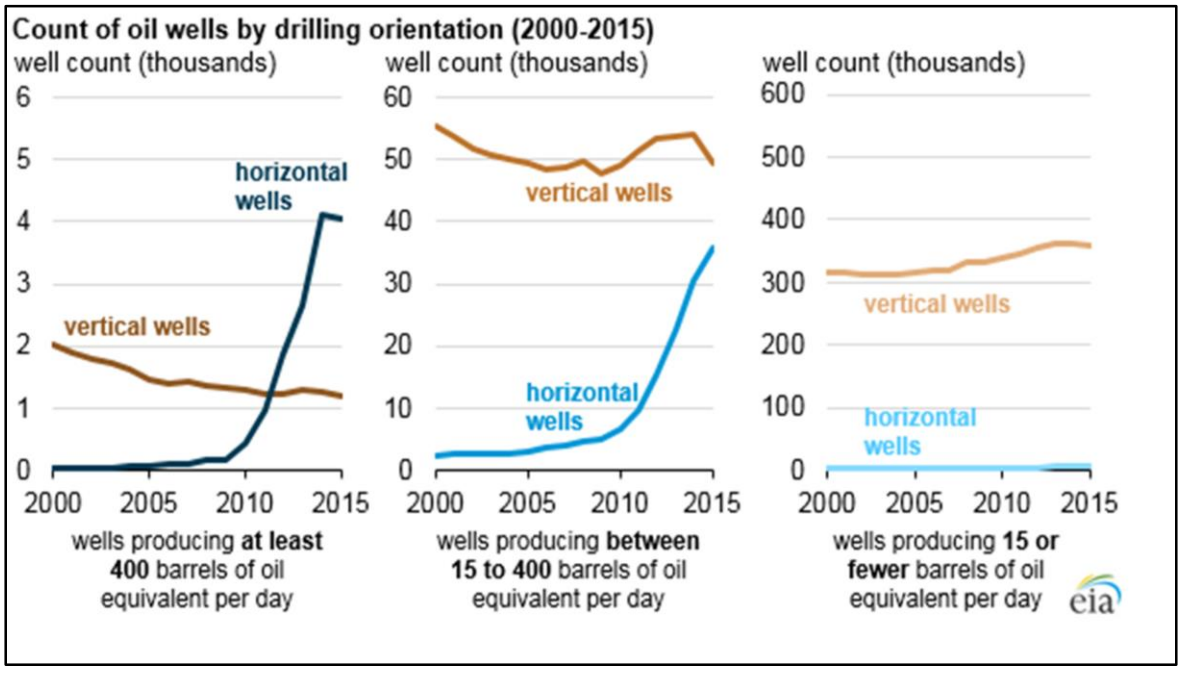


Speed is a second factor that is decreasing the cost of drilling. **More efficient rigs and a more experienced labor force mean greater savings. The average time it takes to drill a well for Chesapeake Energy's Powder River Basin Project dropped from 35 days to 14 in the last two years. The cost has plummeted from $4.5 million to $2.6 million. The average drill cost per foot was lowered from $245 to $143. That means drilling costs have been reduced for Chesapeake by about 42 percent, which offsets the drop in the commodity cost.**

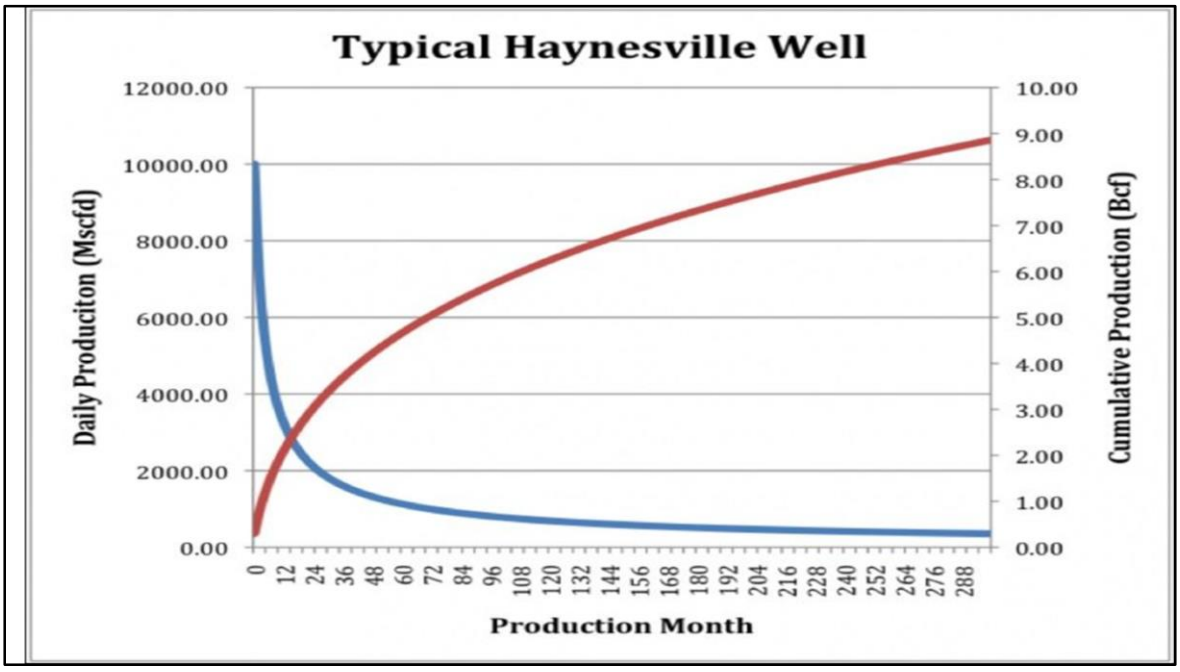
Other companies have reported cost reductions from 2014 to 2015. Bakken well costs dropped from $7.1 million to $5.9 million. Eagle Ford wells went from $7.6 million to $6.5 million. Marcellus wells were reduced from $6.6 million to $6.1 million. Midland Basin wells fell from $7.7 million to $7.2 million and Delaware Basin well costs were lowered from $6.6 million to $5.2 million.



This shows that horizontal drilling is becoming dominant versus vertical



Eclipse Breaks Record Again – New Longest Shale Well in World! June 19, 2017
first "super lateral" Utica well in Guernsey County, OH–the Purple Hayes, at **18,500 feet long**
Outlaw C 11H, a Utica well that is 19,500 feet long horizontally (total measured depth of **27,750 feet**). "Super-Lateral" well, Outlaw C 11H, with a total measured depth of approximately 27,750 feet and a lateral extension of approximately 19,500 feet in 17 days from spud to TD in Utica Shale Condensate



This could be a typical gas well

Shale Region	Production Per Drilling Rig (June 2011)	Production Per Drilling Rig (June 2014)	Percent Change
Niobrara (Colorado)	95 barrels per day	361 barrels per day	280%
Marcellus (Pennsylvania)	2,427 mcf per day*	6,516 mcf per day*	168%
Eagle Ford (Texas)	198 barrels per day	476 barrels per day	140%
Bakken (North Dakota)	213 barrels per day	505 barrels per day	137%

Look at the changing economics

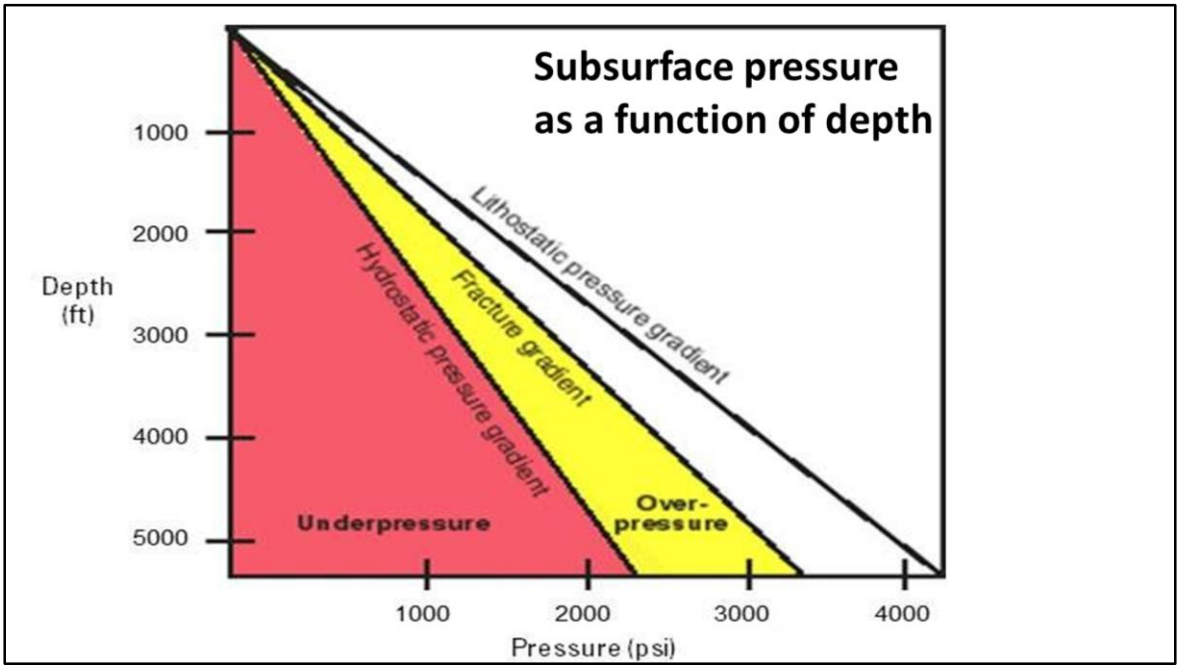
	Annual Percent Decline Forecast					
	Month 1	Month 12	Month 24	Month 36	Month 48	Month 60
Annual Decline (%)		70	30	15	15	10
Daily Production (MMscfd)	10.00	3.00	2.10	1.79	1.52	1.37
Cumulative Production (Bcf)	0.36	2.37	3.30	4.01	4.61	5.14

$$q_t = \frac{q_i}{(1 + bD_i t)^{1/b}}$$

Where,

q_i = Initial gas flow rate, MMScf/Month
q_t = Gas flow rate at time t, MMscf/Month
b = Arps decline Curve exponent
D_i = Initial decline rate, month^{-1}
t = Time in months

An extra effect from hydraulic fracking with very limited projection of impact –Earth Quakes!

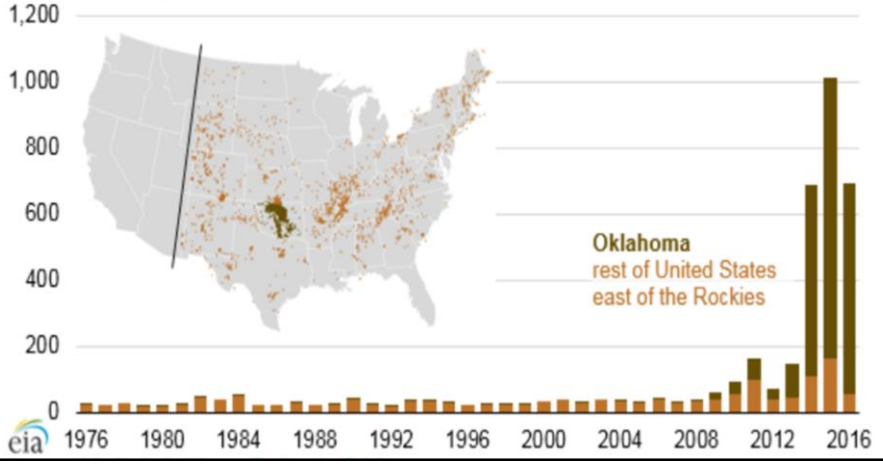


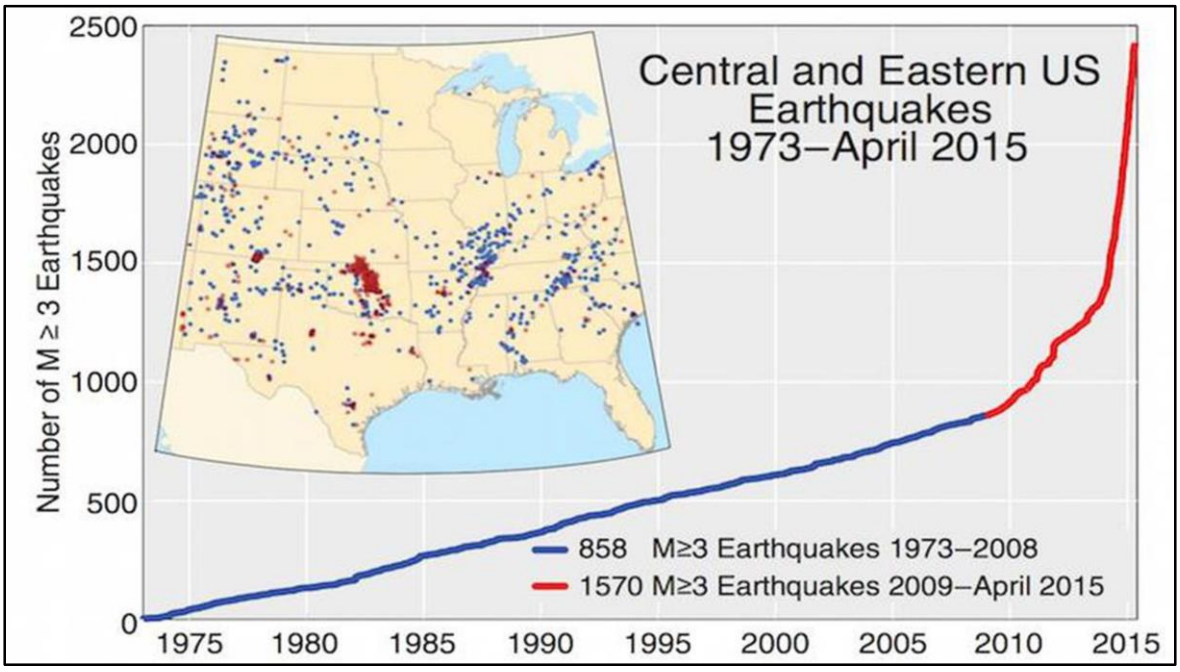
Pressure may be up to 15,000 psi

Lithology	Matrix Density (g/cc)
Sandstone	2.65
Limestone	2.71
Dolomite	2.87
Anhydrite	2.98
Halite	2.03
Gypsum	2.35
Clay	~2.7-2.8
Fresh Water	1.0
Salt Water	1.15
Oil	0.80

Lithology of the media involved in the drilling operations

Earthquake trends in Oklahoma and other states likely related to wastewater injection




Central and Eastern US
Earthquakes
1973–April 2015
Number of M ≥ 3 Earthquakes
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
858 M≥3 Earthquakes 1973–2008
1570 M≥3 Earthquakes 2009–April 2015

Looking to the future – Do we really need the oil/gas?

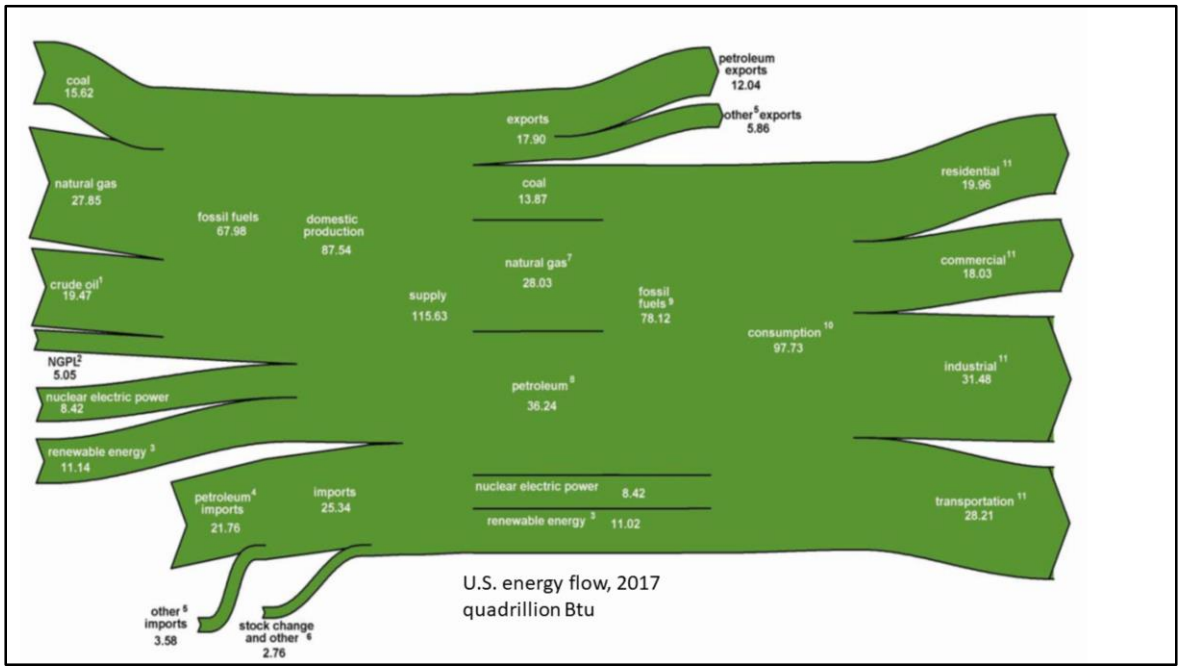
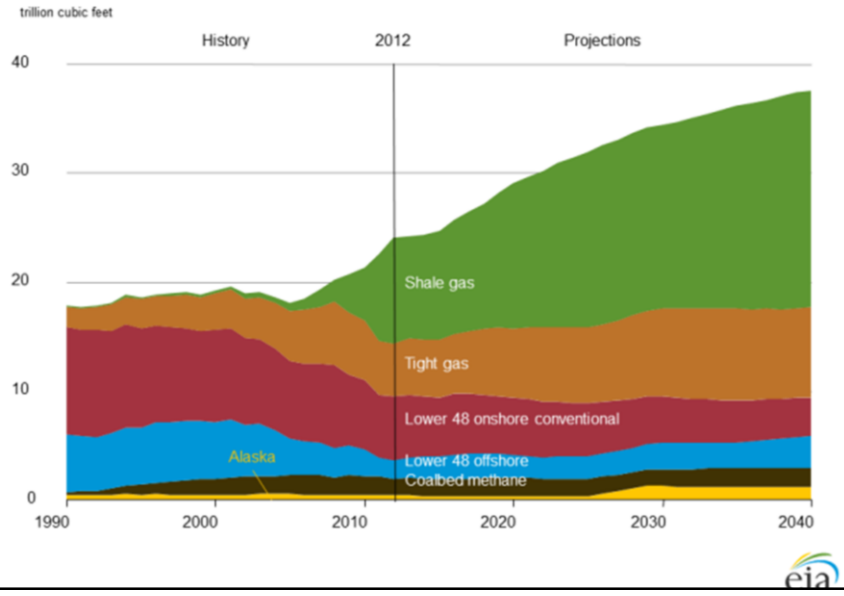
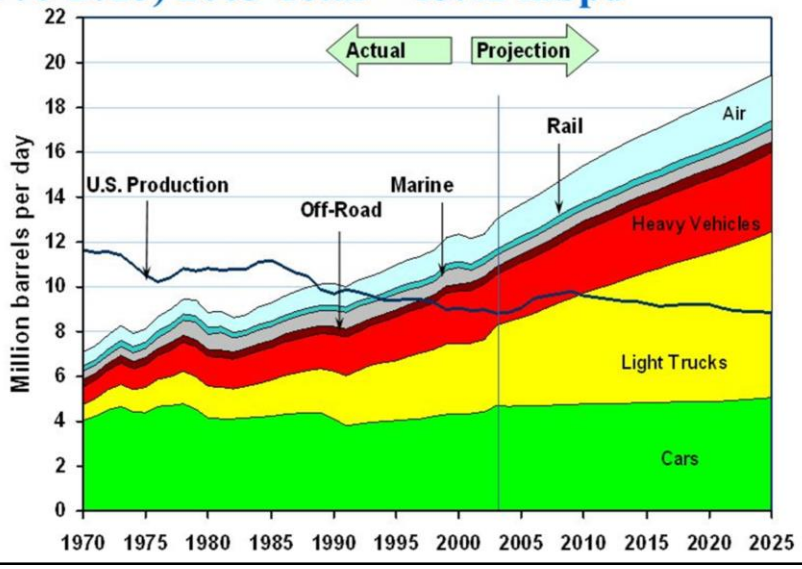
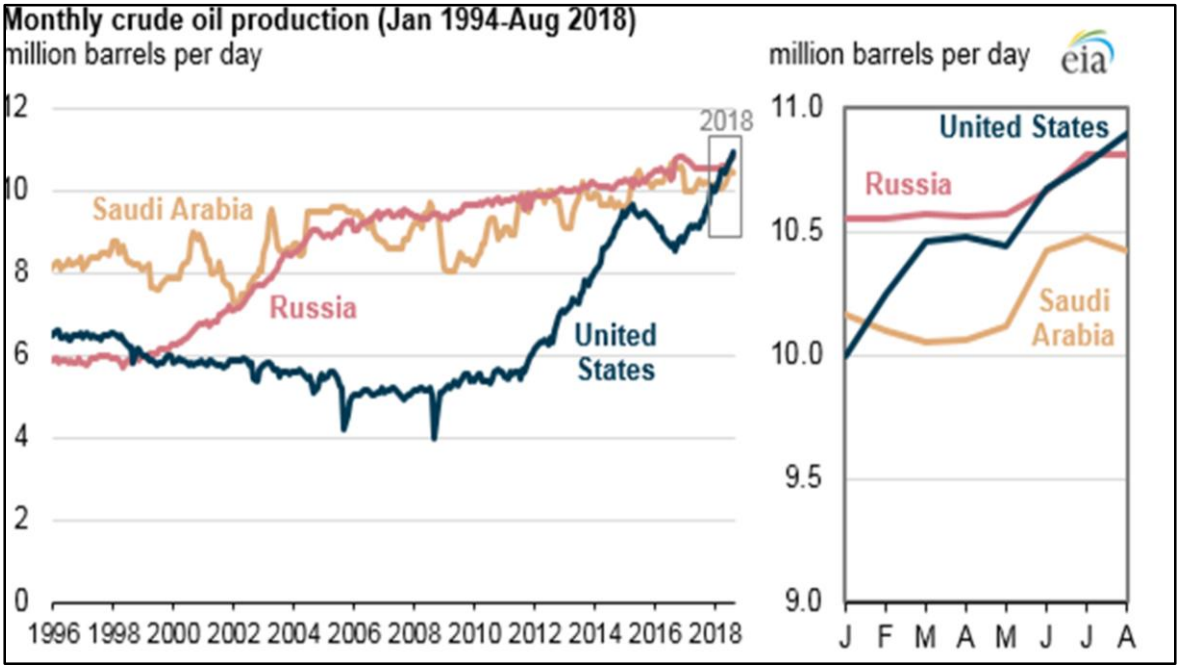

coal
15.62
natural gas
27.85
crude oil[1]
19.47
NGPL[2]
5.05
nuclear electric power
8.42
renewable energy[3]
11.14
petroleum[4] imports
21.76
other[5] imports
3.58
stock change and other[6]
2.76
fossil fuels
67.98
domestic production
87.54
imports
25.34
supply
115.63
exports
17.90
petroleum exports
12.04
other[5] exports
5.86
coal
13.87
natural gas[7]
28.03
petroleum[8]
36.24
nuclear electric power
8.42
renewable energy[3]
11.02
fossil fuels[9]
78.12
consumption[10]
97.73
residential[11]
19.96
commercial[11]
18.03
industrial[11]
31.48
transportation[11]
28.21
U.S. energy flow, 2017
quadrillion Btu

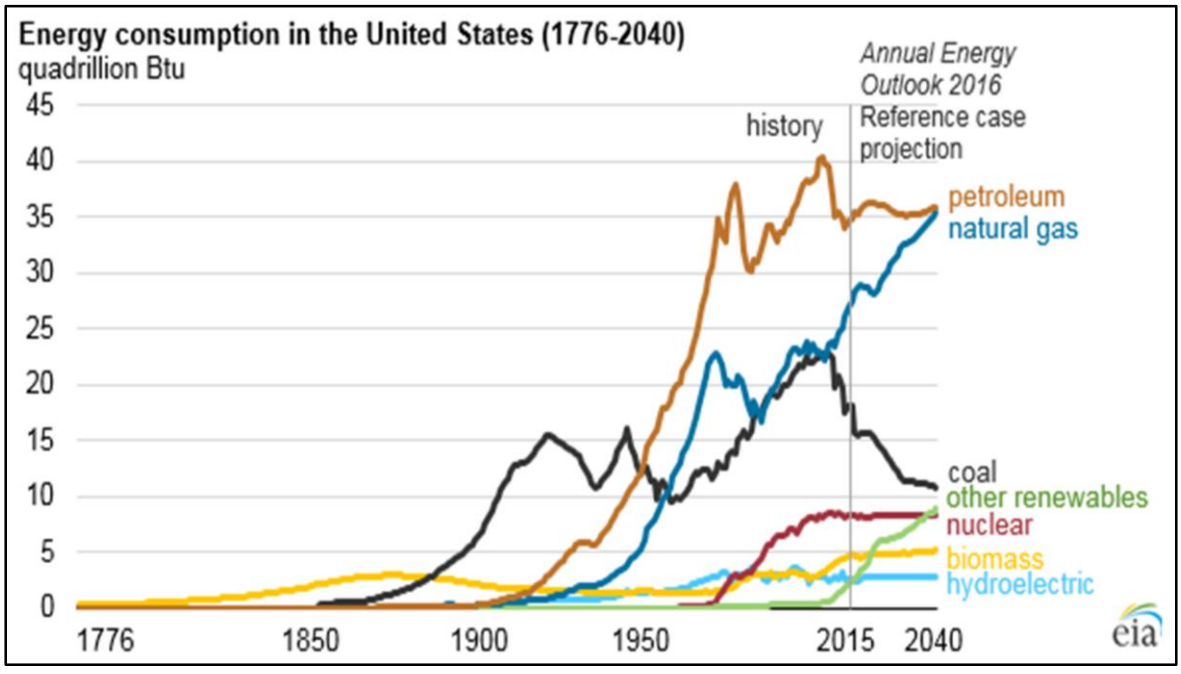
Figure MT-44. U.S. natural gas production by source in the Reference case, 1990-2040

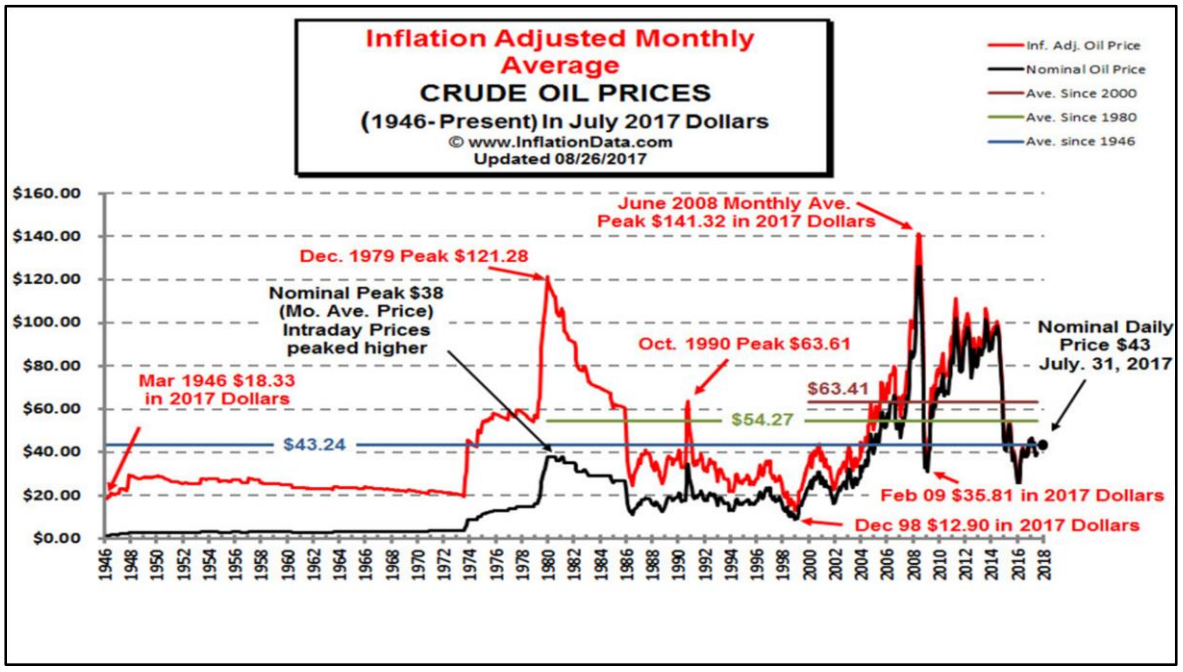


Transportation Petroleum Use by Mode (1970-2025) 2003 Total = 13.42 mbpd

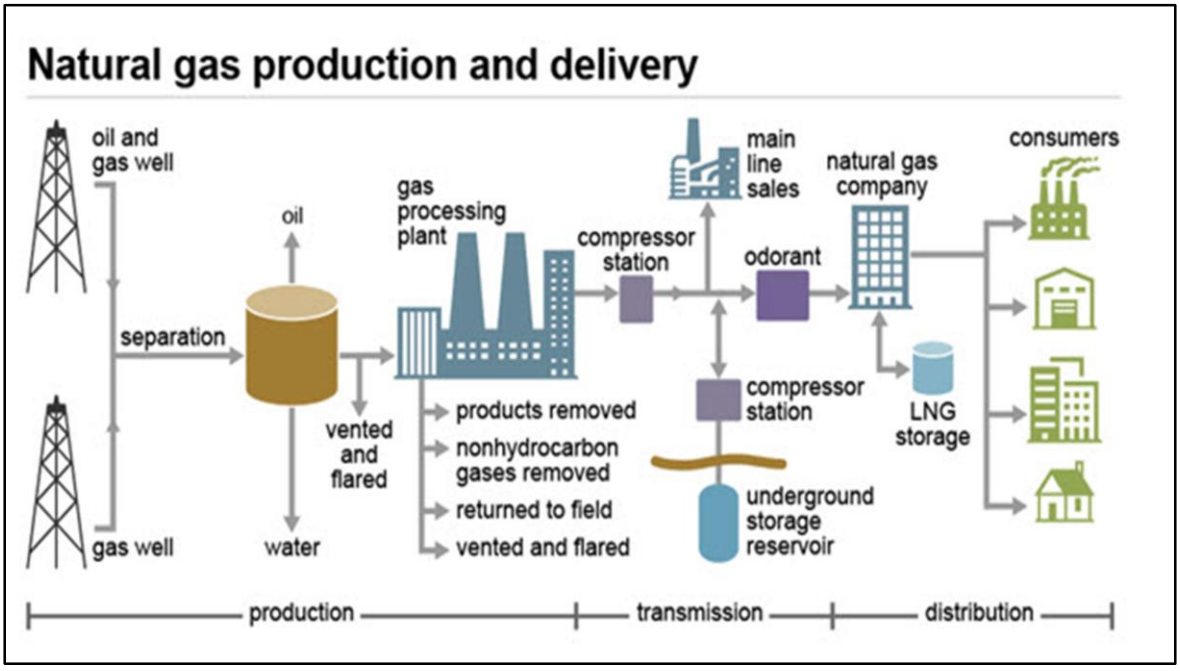


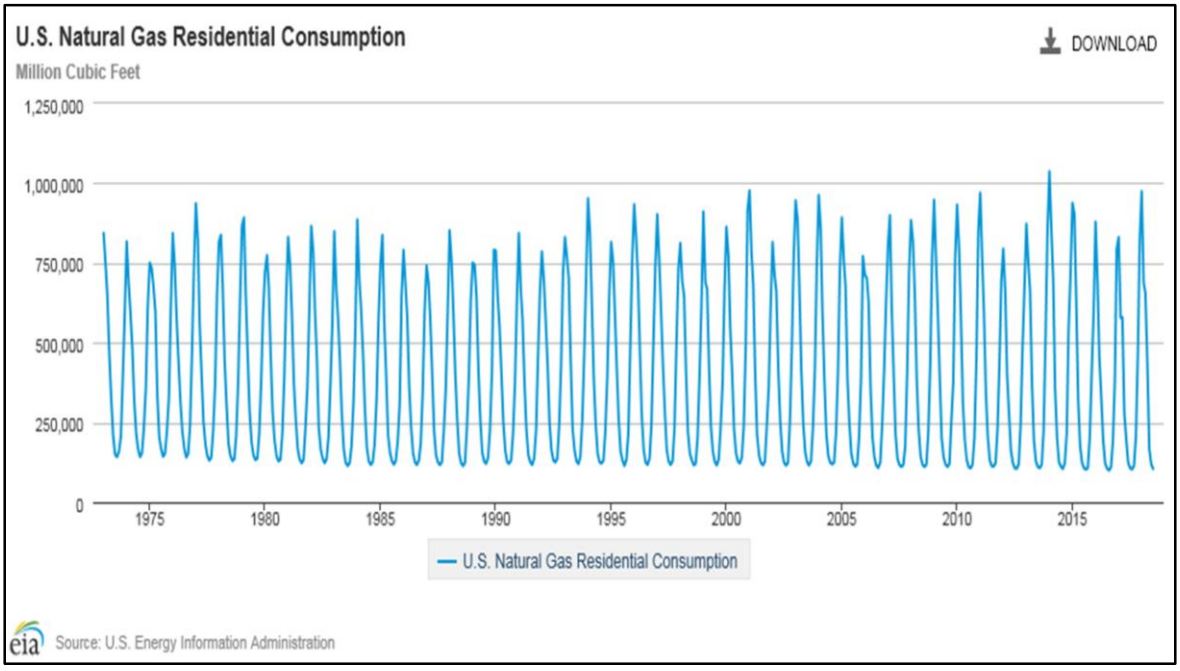

Monthly crude oil production (Jan 1994-Aug 2018)
million barrels per day
12
10
8
6
4
2
0
2018
Saudi Arabia
Russia
United States
1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
million barrels per day
eia
11.0
10.5
10.0
9.5
9.0
United States
Russia
Saudi Arabia
J F M A M J J A

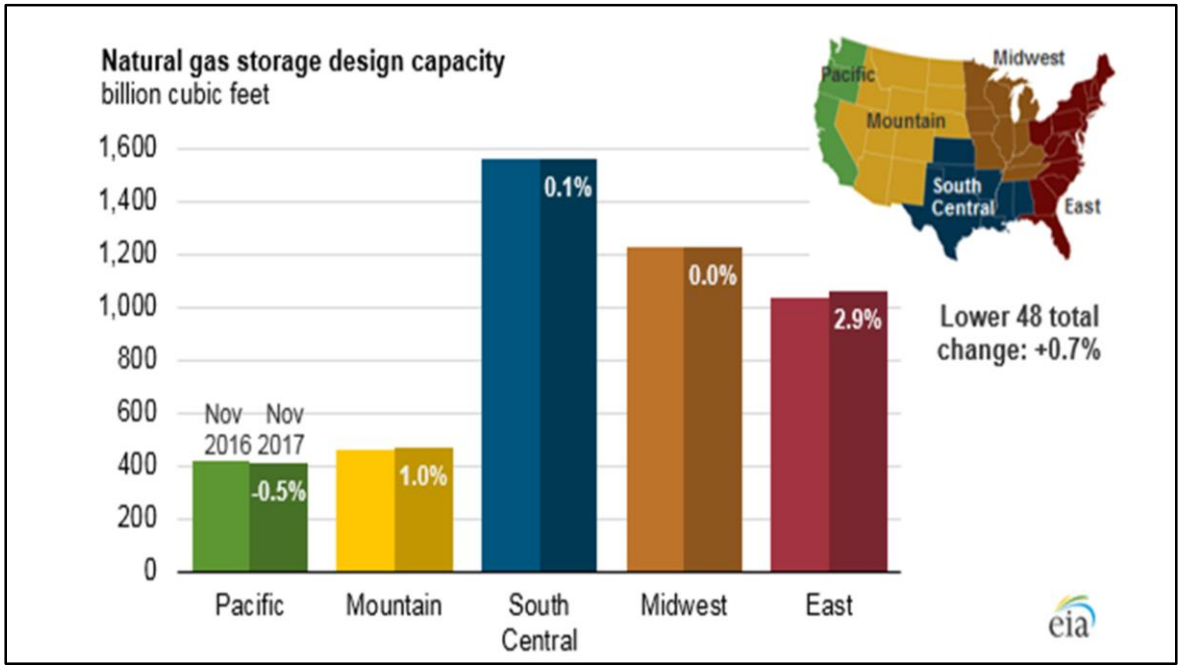

Energy consumption in the United States (1776-2040)
quadrillion Btu
Annual Energy Outlook 2016
history
Reference case projection
petroleum
natural gas
coal
other renewables
nuclear
biomass
hydroelectric
45
40
35
30
25
20
15
10
5
0
1776
1850
1900
1950
2015
2040
eia

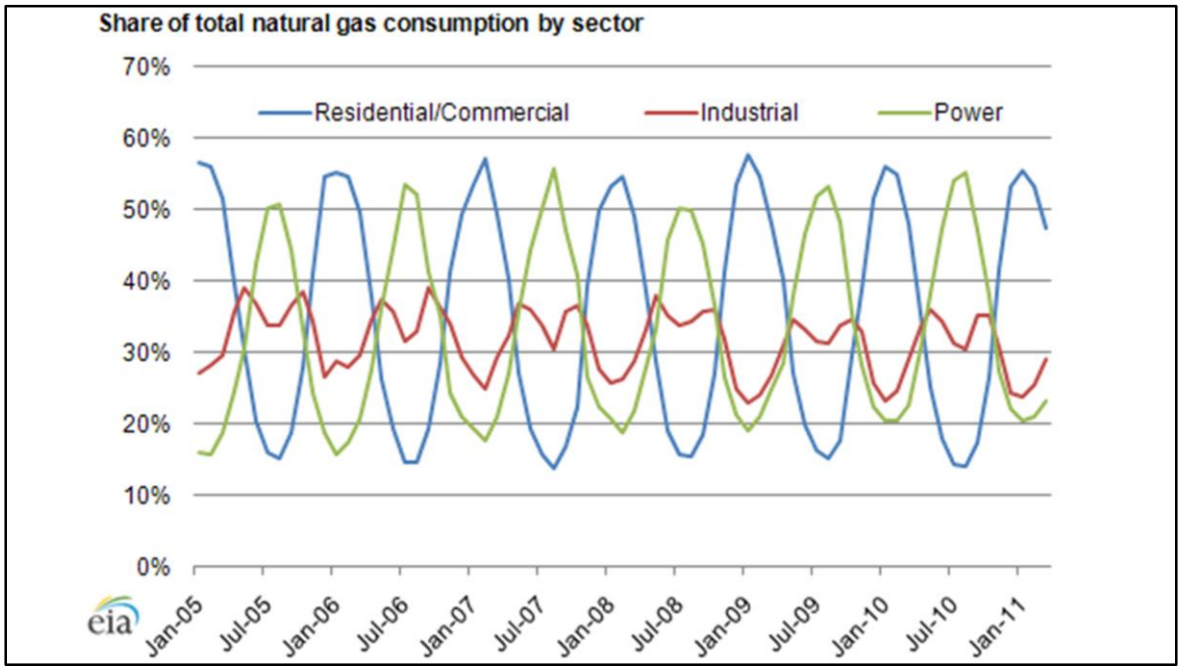

Inflation Adjusted Monthly Average
CRUDE OIL PRICES
(1946- Present) In July 2017 Dollars
© www.InflationData.com
Updated 08/26/2017
Inf. Adj. Oil Price
Nominal Oil Price
Ave. Since 2000
Ave. Since 1980
Ave. since 1946
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
June 2008 Monthly Ave. Peak $141.32 in 2017 Dollars
Dec. 1979 Peak $121.28
Nominal Peak $38 (Mo. Ave. Price) Intraday Prices peaked higher
Oct. 1990 Peak $63.61
Nominal Daily Price $43 July. 31, 2017
Mar 1946 $18.33 in 2017 Dollars
$63.41
$54.27
$43.24
Feb 09 $35.81 in 2017 Dollars
Dec 98 $12.90 in 2017 Dollars
1946 1948 1950 1952 1954 1956 1958 1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018


Gas pipeline
Proposed gas pipeline
Member States of the European Union
Russia
To Shtokman field
To Yamal fields
Barents Sea
Nadym
Teriberka
Ukhta
Punga
Yamal-Europe
Northern Lights
Finland
Norway
Sweden
Vyborg
Volkhov
Gryazovets
Gryazovets–Vyborg
Russia
North Sea
Bacton Gas Terminal
BBL
Nord Stream
NEL
Rehden
Moscow
Brotherhood
Yamal-Europe
Belarus
Germany
JAGAL
JAMAL
OPAL
Olbernhau
Poland
Yamal II
Soyuz
Central Asia
Kazakhstan
Baumgarten Gas Hub
Transgas
TAG
Ukraine
Hungary
Subotica
Romania
Italy
South Stream
Pleven
Bulgaria
Varna
Black Sea
Beregovaya Compressor Station
Caspian Sea
Blue Stream
Ankara
Durusu Terminal
Turkey
Mediterranean Sea
Iraq
Iran


Natural gas production and delivery
oil and gas well
oil
gas processing plant
main line sales
natural gas company
consumers
compressor station
odorant
separation
vented and flared
products removed
nonhydrocarbon gases removed
returned to field
vented and flared
compressor station
LNG storage
underground storage reservoir
gas well
water
production
transmission
distribution


U.S. Natural Gas Residential Consumption
DOWNLOAD
Million Cubic Feet
1,250,000
1,000,000
750,000
500,000
250,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
U.S. Natural Gas Residential Consumption
eia
Source: U.S. Energy Information Administration


Natural gas storage design capacity
billion cubic feet
1,600
1,400
1,200
1,000
800
600
400
200
0
Nov 2016
Nov 2017
-0.5%
1.0%
0.1%
0.0%
2.9%
Pacific
Mountain
South Central
Midwest
East
Pacific
Mountain
Midwest
South Central
East
Lower 48 total change: +0.7%
eia


Share of total natural gas consumption by sector
70%
60%
50%
40%
30%
20%
10%
0%
Residential/Commercial
Industrial
Power
eia
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11