HYDRAULIC FRACTURING

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Introducing Team B

Presentation Layout as Follows:

Emma: History and introduction to Hydraulic Fracturing

Ally: What is hydraulic fracturing? How does it work? Which countries use it?

Rebecca: Environmental Impacts

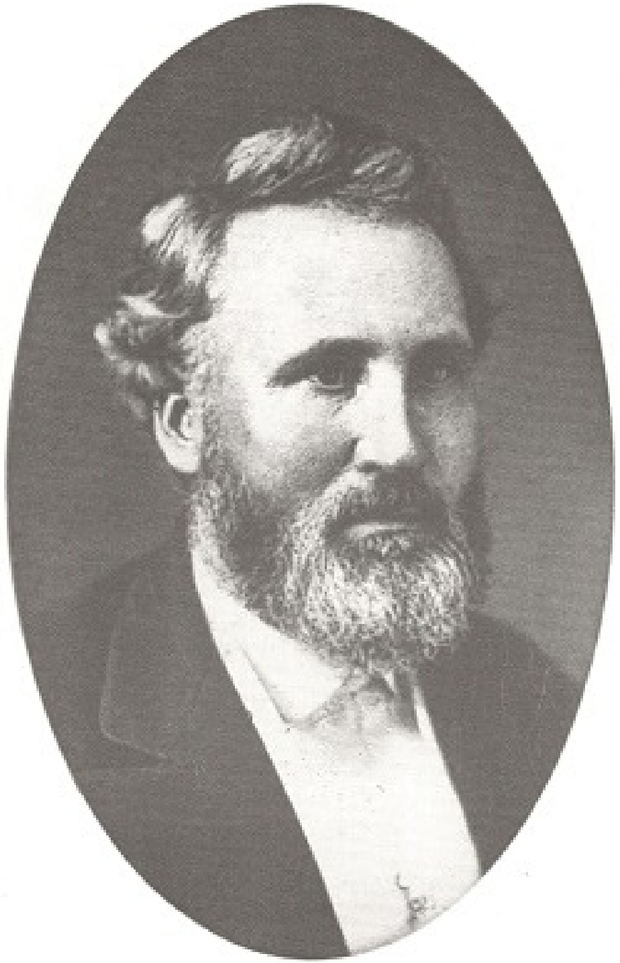
Alexa: Health and Social Risks

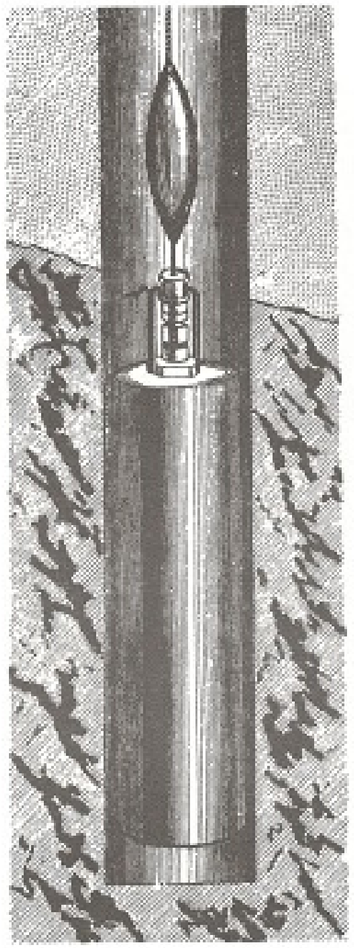
Beverly: Economic Impacts

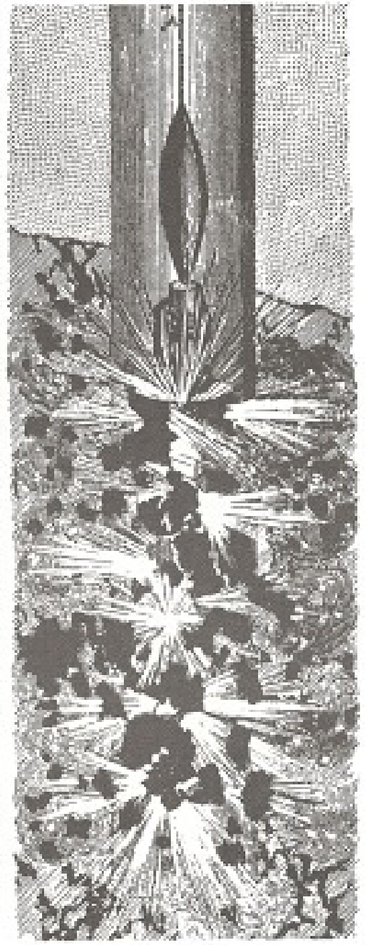
Magena: Politics and Public Opinion

Hortense: Regulation & Laws

Manon: Provide an in-depth case study of Hydraulic Fracturing







History of Hydraulic Fracturing

Image Courtesy of Drake Well Museum, Early Days of Oil, Princeton University Press.

Early Roots

- Modern hydraulic fracturing's roots began in 1865. Lt. Col. Edward A. L. Roberts patented the "exploding torpedo"
- This involved firing high explosive charges into oil wells to blast fractures into oil bearing sand

- 1866, Roberts was awarded U.S. Patent No. 59,936 for what would become known as the Roberts Torpedo.

- 1868 nitroglycerin was preferred to black powder, despite its frequently fatal tendency to detonate accidentally.

- Roberts died March 25, 1881

- His heirs sold Roberts Petroleum Torpedo Company to its employees, who continued in business as the Independent Explosives Company.

Rise of Commercial Hydraulic Fracturing

1945

First hydraulic fracturing takes place in Oklahoma and Texas

Technique had been developed and patented by Stanolind (later known as Pan American Oil Company)

1953

The license was extended to all qualified service companies..

1980s

A sudden technological advance in fracturing shale formations led to the U.S. vastly increasing its oil and especially natural production that continues to this day.

HYDRAULIC FRACTURING TODAY

Where?

- Only **USA, Canada, Argentina** and **China** extract enough volumes of shale gas and shale oil to market them commercially.
- USA owns 85% of the total number of hydraulic fracturing spreads
- Possible new locations; Colombia, Mexico, Russia and Algeria.

What are the figures?

- Hydraulic fracturing: 6.44 million barrels of crude oil per day in 2018, or 59 percent of total American production
- In the United States also produced 53 billion cubic feet of natural gas per day (two-thirds of total domestic production)

What is it?

Hydraulic fracturing today, known as fracking, is a technology and process used to recover oil or natural gas trapped in non-porous or “tight” rock formations such as shale - these formations were previously too expensive to produce efficiently.

Why?

- There are about 45 countries with proven or probable reserves of shale, but not all are exploitable, some for technical reasons and others because of the low quality of the hydrocarbons or too expensive.
- Cheaper fuel option
- Lower trade deficit
- Great employment opportunities

WHATS FRACKING GOT TO DO WITH WATER???

- Extensive water use for hydraulic fracturing
- Median shale-gas water use ranged from 390,000 to 6.27 million gallons per well, while shale-oil use ranged from 70,000 to 2 million gallons of water per well.
- Fracking's water footprint is intensifying
- Huge increases in both water use and wastewater in the years spanning 2011 to 2016.
- Researchers found that water use per well rose by up to 770 percent while wastewater (flowback and produced water) volumes increased by a high of 1,440 percent within one year one of production.

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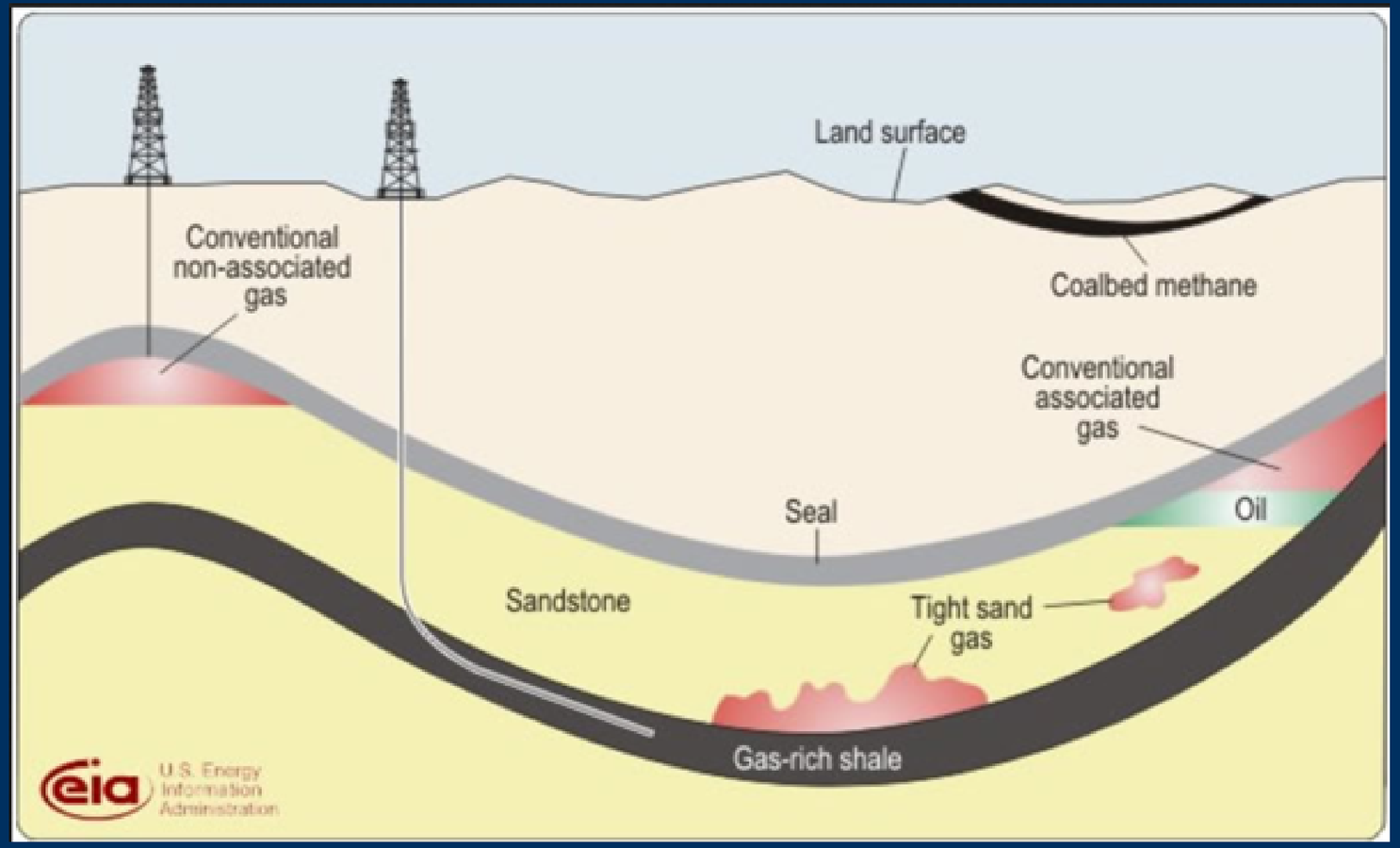
What's the difference between conventional and unconventional?

Conventional:

- Gas in porous layer
- Constrained by impermeable layer above
- Flows naturally to surface after drilling

Unconventional:

- Gas or oil reserve trapped in non-porous or impermeable layer
- Does not flow naturally to surface
- Must use horizontal drilling and high pressure hydraulic fracturing to release gas
- Much more difficult to extract



US Energy Information Administration

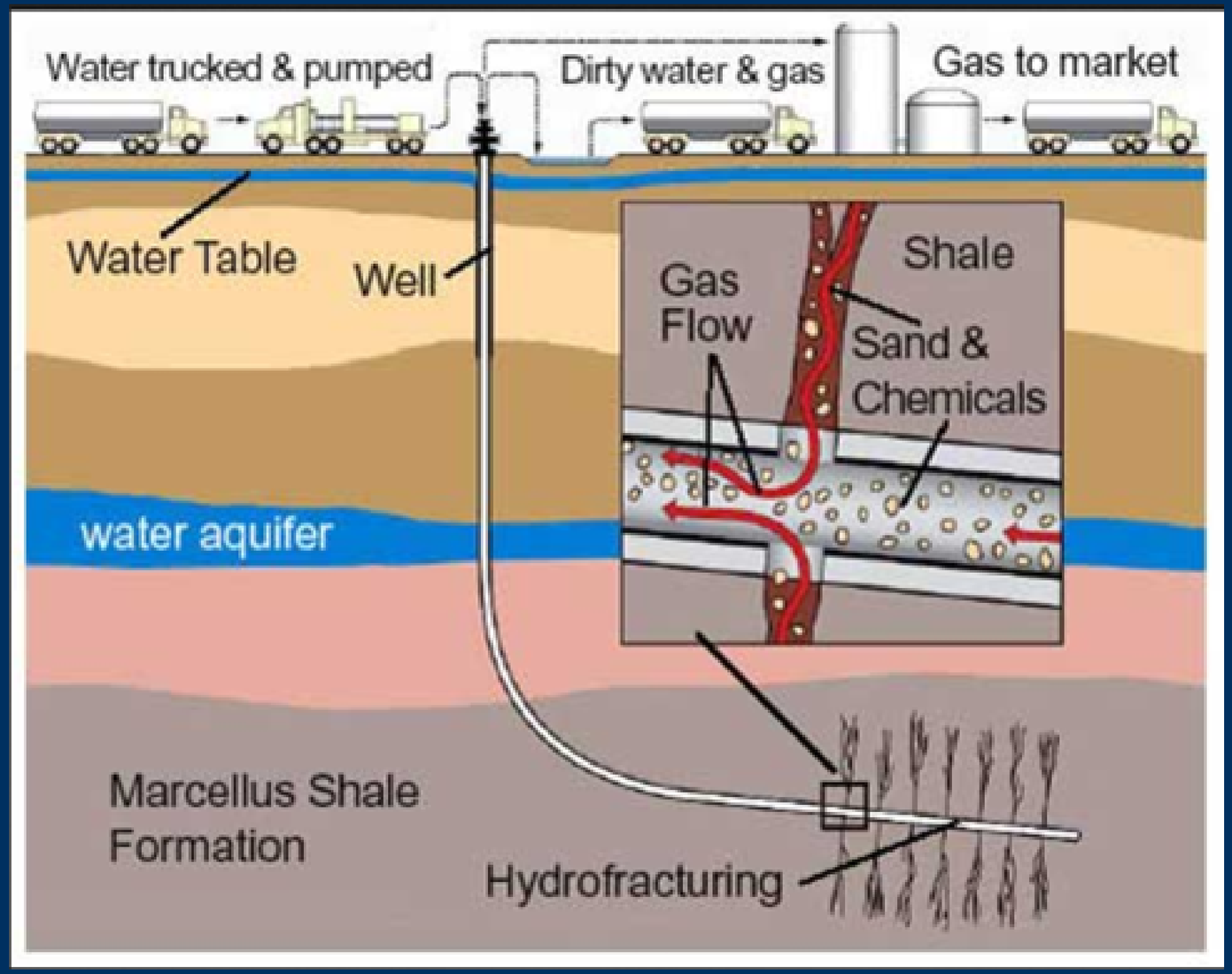
What is "fracking"?

Process

1. Seismic exploration of the region
2. Drill vertical well
3. Drill horizontal well
4. Use explosives to create little holes in drill casing
5. Force water and proppants at 5000psi (very high pressure) into holes
6. Cracks propagate up to 305m outward into the rock
7. Gas flows out with "flow back" or "produced" water to surface
8. Water treated, reused, recycled or disposed of

Some key terms:

Shale: A fine grained, sedimentary rock formation
Proppant: Sand and chemical mix injected into artificially formed cracks in the rock to facilitate gas flow
Plays: Industry term for gas fields, sites of conventional and unconventional gas extraction
Tight: Tight in this context means impermeable (ie. tight sands)



Locations of major shale basins in North America

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

US Energy Information Administration, 2011

Marcellus:

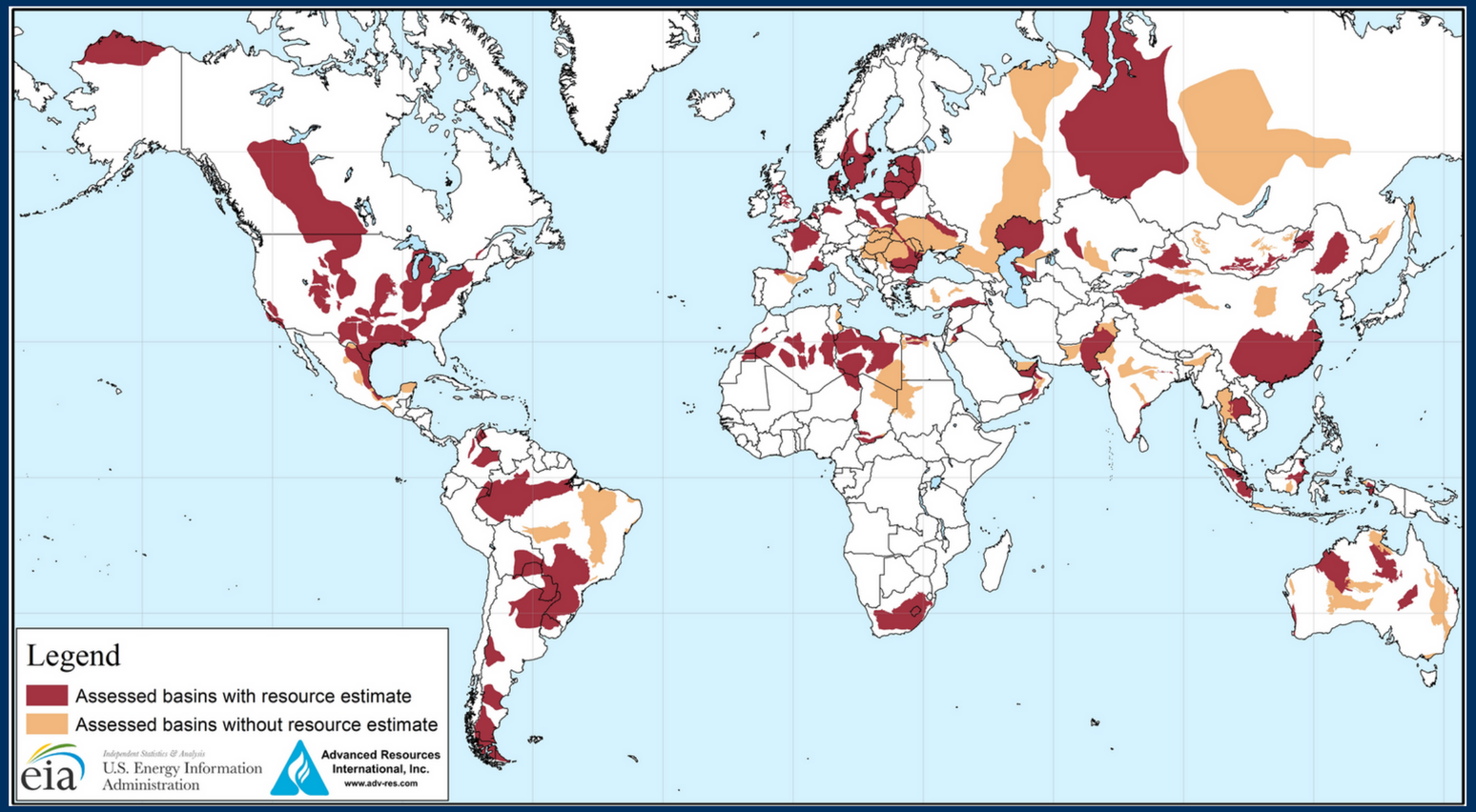
- Largest natural gas reserve in the United States
- Spans Ohio, West Virginia, New York and Pennsylvania
- Ability to supply 45 years of US domestic natural gas consumption

Implications

- Abundance of natural gas in the US
- Lowered gas prices
- Electricity to power factories half as cheap as Chile or Mexico

Locations of shale basins throughout the world

42 shale gas basins in 32 countries



US Energy Information Administration, 2011

Key Points from US EIA assessment

- Shale reserves are plentiful
- As abundant as conventional gas reserves
- 5760 trillion cubic feet of recoverable gas
- Valued at trillions of dollars
- China, EU and US have shale gas deposits
- Could alter global geopolitics around fossil fuels

Environmental Impacts

4 main concerns:

1.Water consumption
2.Water pollution
3.Climate change/ air pollution
4.Land use

*Plus 3 relatively minor concerns worth mentioning

Shutterstock/FerrizFrames

Water Consumption

HOW MUCH?

- over lifetime (initial fracturing, refracturing, end-of-job flushing)
- 8,000-80,000 m3
- less than half recovered

CONSEQUENCES

- lower lake levels/ intermittent streams
- shift in ecosystems
- loss of aquatic and riparian habitat

POTENTIAL

- use gases (CO_2, liquid propane) instead of water
- recycle flowback water

*However, fracking is still the **least** water intensive non-renewable energy source!

Energy source (data source)	Water for extraction (L/GJ, gallons/MMBTU)	Water for extraction and processing (L/GJ, gallons/MMBTU)	Water consumption intensity of electricity generation (L/MWh)[a]
Natural gas, conventional (42, 50)	0.7, 0.2	6.7, 1.9	See below
Natural gas, unconventional (47–49)	8.6, 2.4	15, 4.1	See below
Natural gas combined cycle (once through)	See above	See above	520
Natural gas combined cycle (closed loop)	See above	See above	850
Pulverized coal (once through) (47–49)	9.0, 2.5	27, 7.5	1,400
Pulverized coal (closed loop) (47–49)	9.0, 2.5	27, 7.5	1,900
Saudi Arabian crude (47)	79, 22	110, 32	NA
Oil shale (51)	200, 57	240, 67	NA
Oil sands (47)	NA	110, 31	NA
Nuclear (once through) (47–49)	14, 4	47, 13	1,700
Corn ethanol (unirrigated) (47, 48)	300, 83	430, 119	2,100
Corn ethanol (irrigated) (47, 48)	14,000, 3,800	14,000, 3,800	16,000
Solar photovoltaic (47–49)	0, 0	0, 0	10
Concentrated solar power[b] (47, 48)	NA	NA	3,100
Wind[a]	0, 0	0, 0	4

(Jackson et al., 2014)

Water Pollution

WHAT?

- thousands of products; ~150,000 L per-fracturing
- acids, borate salts, friction reduces, proppants, biocides etc.
- "trade secrets"

CONSEQUENCES

- leaks WILL happen
- this impacts ecosystems in various ways; mortality, disrupts reproduction, antibiotic resistance.....AGAIN, we often don't know

***BUT! Coal causes massive acid, sediment, mercury runoff**

Climate Change and Air pollution

PROS

- natural gas creates less than half the CO2 emissions of coal
- releases nearly 0 SO2, Hg; less NOx and particulates than coal (no fly ash!!!)

CONS

- natural gas = mainly methane (21-23x more potent than CO2)
- methane often escapes before it is burnt
- lifecycle emissions

POTENTIAL

If leaks "can be minimized, the GHG benefits of [switching from coal to natural gas] would be substantial, particularily as a bridge to a renewables-based future" (Jackson et al., 2014)

Land Use

PROS

- 1 well = only 3 hectares surface disturbance

CONS

- combined effects are important (100s of wells)
- significant habitat fragmentation can impact animal migration

***Coal production: impacts macroscale topography (mountaintop removal and pit mining), major soil degradation, dust, complete habitat destruction etc**

North-western Colorado valley

Susan Heller/Getty images

Walter Energy’s Wolverine coal mine, BC

Mining [dot] com

Worth Mentioning...

NOISE POLLUTION

- ~80-250 days of noise pollution per well during site prep. and fracturing

SEISMIC ACTIVITY

- fluid injection into disposal wells has been know to cause "felt" earthquakes (still minor)

RADIOACTIVITY

- naturally occuring radioactive materials can be brought to surface in flowback

Health Risks & Social Impacts

1. Individual Community Member

2. Community as a whole

3. Mobile Workers

Individual Health Risks & Social Impacts

- Physical symptoms:
  - Fatigue, headaches, ocular and dermatologic irritation, confusion, and delirium
- Neurological and neuropsychological symptoms:
  - Problems with balance, disorientation and fainting, cognitive deficits, developmental delays, and neural tube defects in infants
- Increased respiratory, gastrointestinal, immunological, endocrine and sensory illnesses
- Increased rates of cancer and infertility
- Increased sense of powerlessness , fear, betrayal, guilt, anger, stress, anxiety, depression and sleep disturbances

Community Health Risks & Social Impacts

- Communities most effected by fracking:
  - Rural, Indigenous, low-income
- Two opposing views:
  - Fracking as a means to support, promote and encourage thriving in a community (job creation)
  - Fracking is a disruptor to community thriving (change in way of life)
- Gender/sex imbalances within fracking communities
- Increased risk of tremors and earthquakes
- Growth in population often overwhelms the existing healthcare infrastructure
- Intergenerational impacts contributing to historical trauma

Mobile Worker Health Risks & Social Impacts

- Men move to fracking communities for increased wages, leaving behind support systems and their normal routines
- Perpetuates "frontier masculinity"
- The social isolation may result in substance misuse and violence
- Men sometimes bring their families with them
- Many workers (and their families) end up homeless due to unavailability of housing or extreme rental prices
- Host communities are sometimes hostile towards workers
- Lack access to resources and health benefits

Economic Impacts

Beverly Ma

Economic Development

Hydraulic Fracturing & the U.S

Economic Development

- Jobs and Employment opportunities
- Unconventional gas is "cheaper" than conventional gas
- Presents the opportunity for nations to produce their own gas and eliminate dependency on outside suppliers.
- Unclear Profitability

Hydraulic Fracturing & the U.S

- Within the U.S itself, the abundance of resources from fracking has drastically reduced the prices of shale gas
  - 50 - 66% cheaper than gas from a conventional well.
  - i.e Abundance of Marcellus Shale Reserve in Pennsylvania

- As a result of cheaper gas, the U.S has become a very attractive place for manufacturing industries to invest in.

- Geopolitical relationships

Politics and Public Opinion

Magena Carlson-Rink

Pro-Fracking Framing

Energy Independence

- Become a net exporter of energy
- Power
- Geopolitics
- Identity

Clean Energy Transition

- Shale gas as a cleaner fossil fuel to help transition away from oil and coal
- Low Emissions

Economic Development

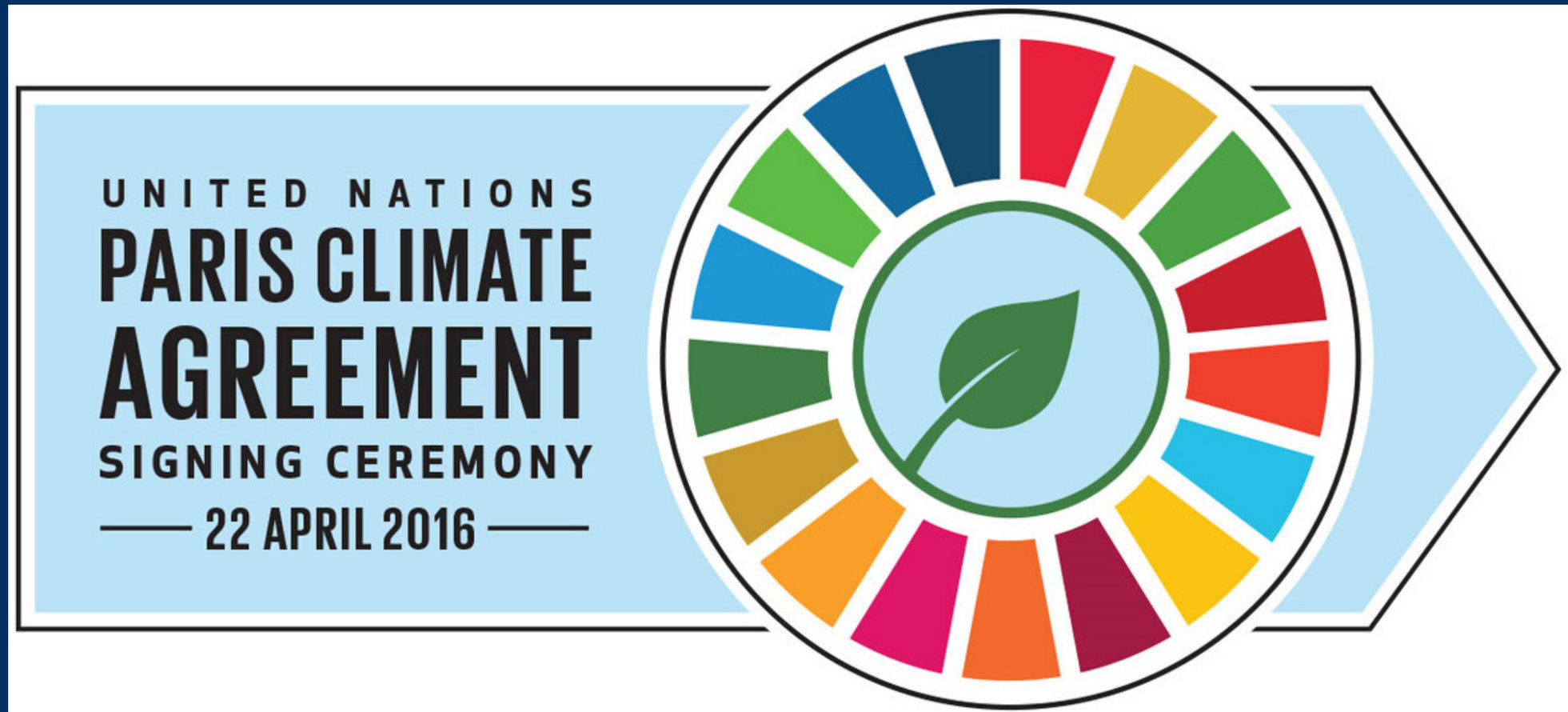
- Jobs
- Infrastructure
- Economic Investment

- Distrust of energy projects
- Corruption, Lobbying and Biased Representation
- Environmental Impacts and GHG emissions
- Land disputes and Indigenous Rights
- Human Health

Anti-Fracking Activism

Political Priorities

- Environmental vs. Economic
- Local Communities vs. Large Projects



Case Study: Poland and Russia

- Fracking is a geopolitical issue
- Poland wants energy independence from Russia due to the history of the Soviet Union
- 13% of energy in Poland comes from imported gas
- 80% of the imported gas comes from Russia
- Overwhelmingly positive media coverage
- Fracking heavily supported

Final Thoughts

- Influence of Political Ideologies
- Misinformation
- High Levels of uncertainty
- Polarization

Regulations & Laws

I) Legal context

Evolution, news principles & lobby
International law & treaties

II) Case study : The US

Evolution of regulation in US
Pro vs Anti fracking

III) The others... ?

Examples of others legislation : Canada, France, European Union, United-KIngdom..

LEGAL CONTEXT

Evolution

Legal vaccum

No regulation & no code

Lack of informaitons

Legal context = vague

Varies in countries & regions

International Law

Precautionary principle 1982,

World Charter for Nature 1987,
Montreal Protocol 1992,
Rio Declaration1997,

Kyoto Protocol Environmental responsibility 1992,
Rio Earth Summit

Lobby

Difficulty in implenting effective legisaltion on hydraulic fracturing

Tension betweens industrial & l+ between actors responsbile for envionmental regulation

Influence of lobby

CASE STUDY : American legislation

A**nti-fracking States :**

- **2010: Wyoming** is the first state to require companies to disclose the contents of their fracturing
- **2010: David Paterson, Governor of New York State** signed an executive order instituting a seven-month moratorium on all gas drilling.
- **2013, New New York State Assembly** adopted a two-year moratorium on fracturing to protect its water resources.
- **2012, the State of New Jersey** votes for a one-year moratorium, then the state governor, Chris Christie, supports a bill that definitively bans all fracking in the state.
- **2012, North Carolina**, Governor Beverly Perdue opposed a veto to a bill that wanted to suspend the moratorium that banned all fracking in the state
- **2013, Michigan** joins other states in the Great lakes region that have been implementing a new legally binding interstate framework called the Great Lakes Compact since the early 2000s. This framework limits or prohibits all massive and wasteful water withdrawals.
- **2012, Vermon**t became the first state in the United States to ban hydraulic fracturing.
-**2014, New York** became the second state to issue a complete ban on any hydraulic fracturing due to potential risks to human health and the environment.
- **2017, Maryland** became the first state in the US with proven gas reserves to pass a law banning fracking

Pro-Fracking :

On the other side : some laws limit the ability of local authorities to interfere with the issuance of drilling permits. For example, a law passed in Pennsylvania, the House of Bill 1950 or Act 13, requires local communities to accept drilling throughout the Marcellus Shale gas basin, including residential
areas.

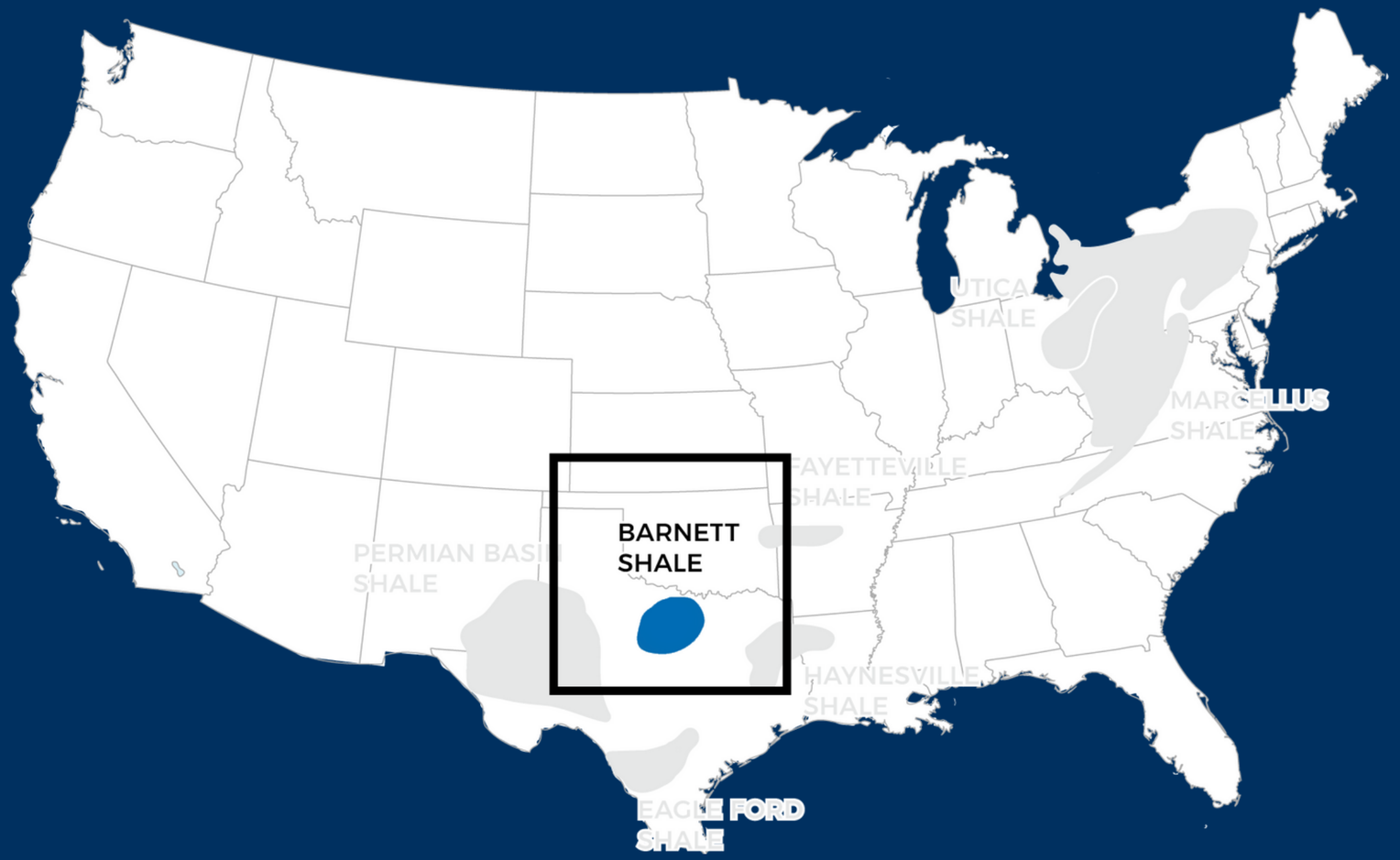
& the others...?

Canada :
Four out of Canada's 10 provinces currently have province-wide bans on fracking: the provinces of New Brunswick, Newfoundland, Nova Scotia and Quebec

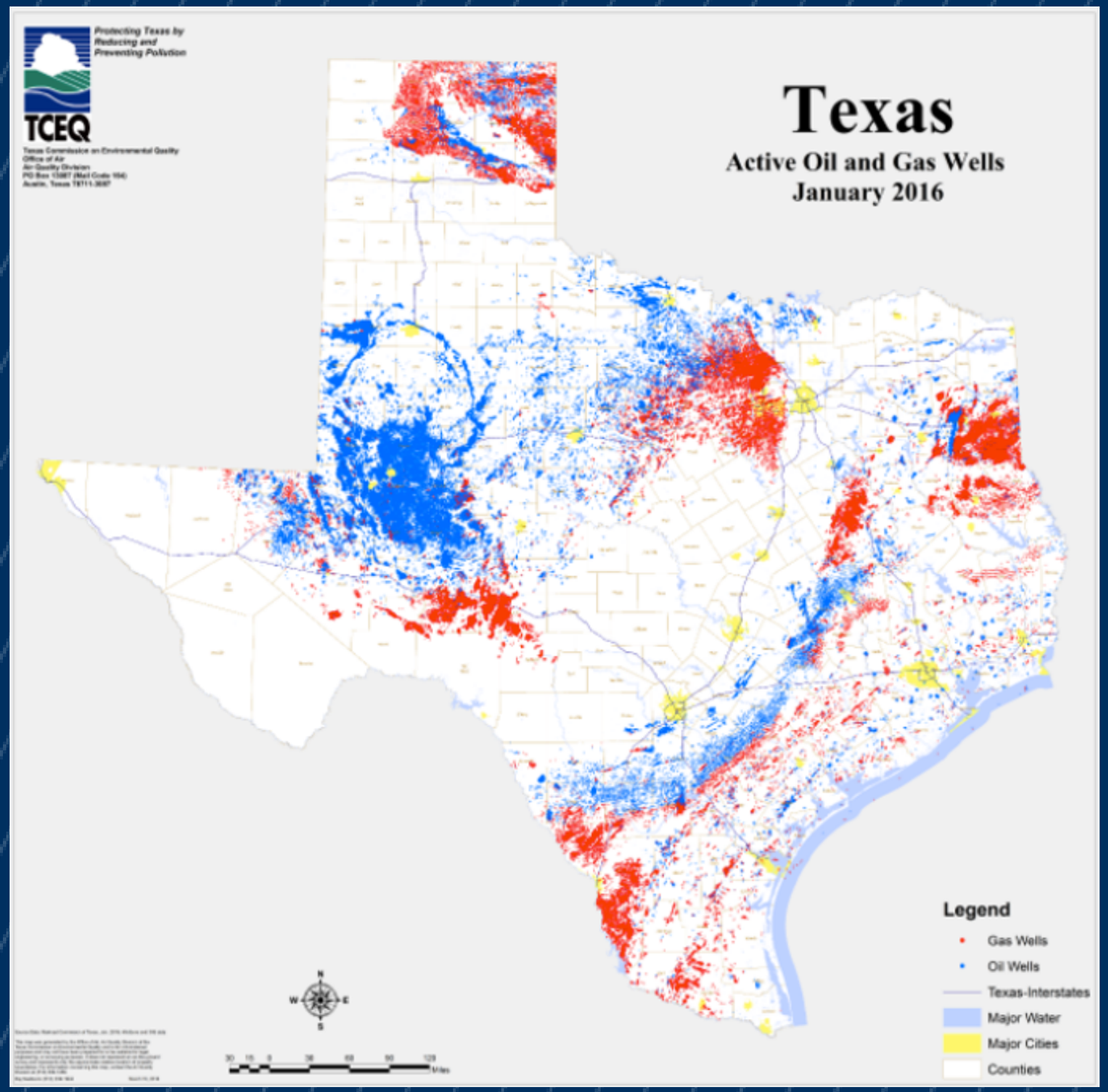
France :
France has launched a reform of its mining code and banned fracturing for gas exploration and exploitation in 2011. France thus became the first country to ban hydraulic fracturing, And this decision was deemed to be in conformity with the French Constitution by the Constitutional Council

UK :
In March 2019, the High Court found the UK government's policy was unlawful and failed to consider the climate impact of shale gas extraction.
In November 2019 the UK government imposed a moratorium against fracking

Barnett Shale, Texas, USA



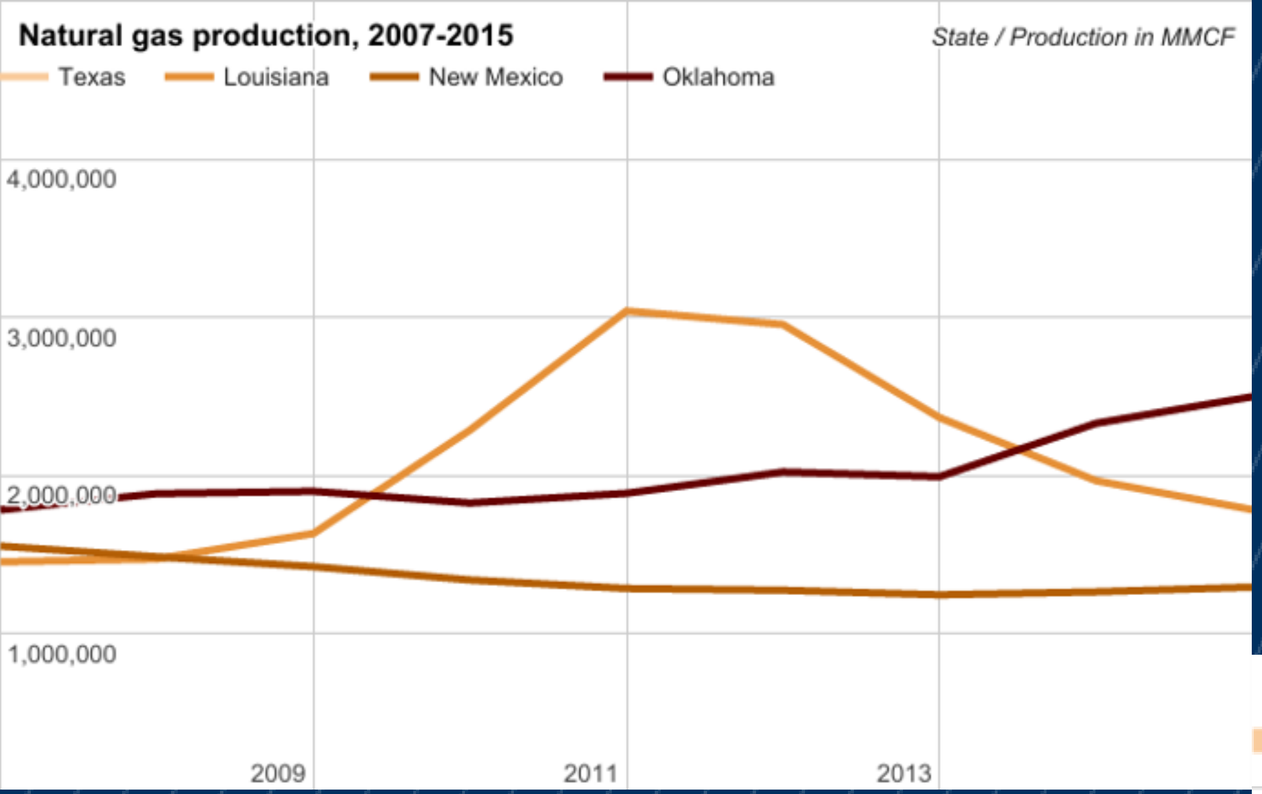
Barnett Shell History



- The Barnett Shale Formation was found in the early 20th Century
- First producing well drilled in 1981 by Mitchell energy thanks to the hydrofracturing technology
- Production increased in the early 2000s with the development of new wells near urban areas and populated areas
- Affects at least 18 Counties through Texas
- It is one of the largest onshore natural gas field in the USA (13 000km2)

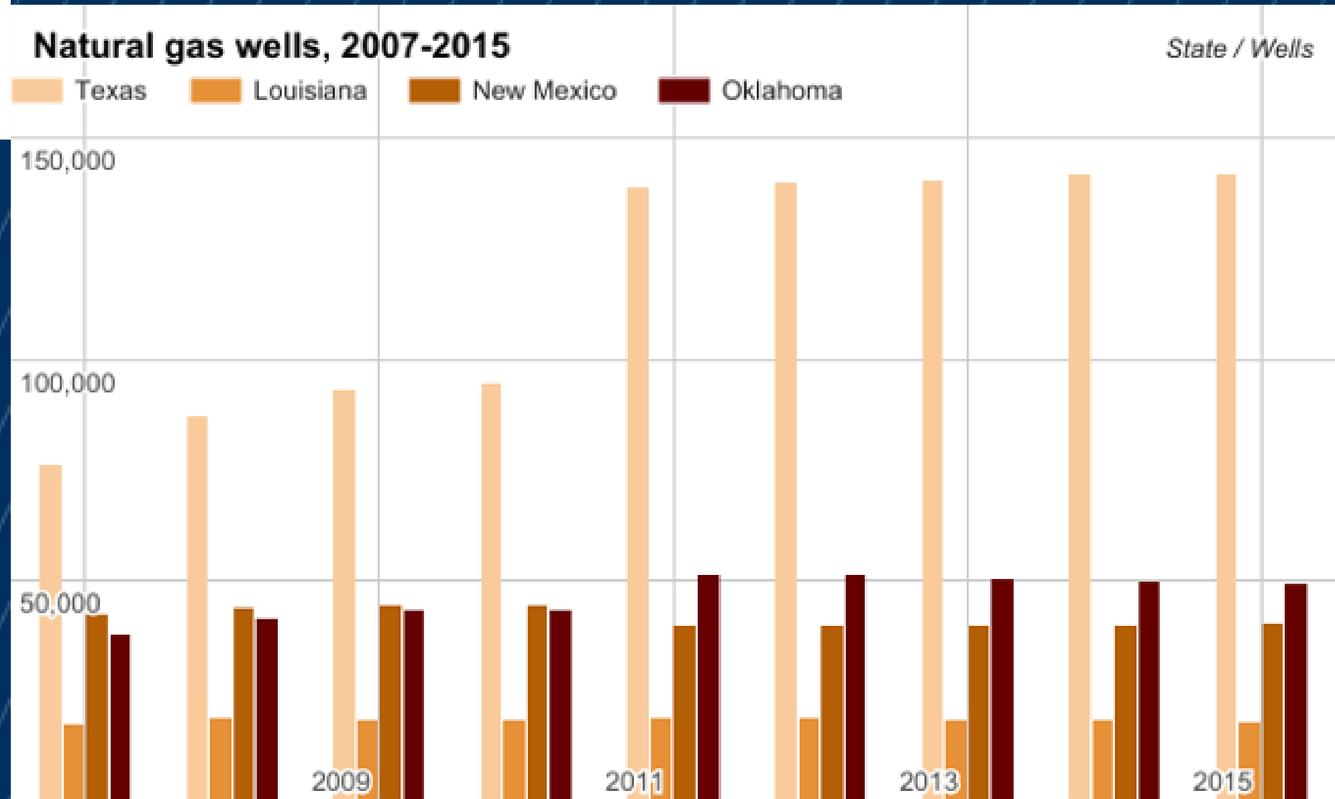
Gas Production

- In 2019 the four main counties (Denton, Johnson, Tarrant, and Wise), each of them has an estimated production over 430 million cubic feet of dry natural gas per day accounted for more than 80% of the region’s output.
- Production started to decline in 2012 but still represents 8.6% of Texas's natural gas production and 2.3% of the US's supply



Natural gas production

Natural gas wells



Economic Benefits

- 2015 Perryman Group study estimated the profit of the business activity in the region (for the main counties) from the Barnett Shale to be $11.8 Billion in gross product per year and generating 107,650 permanent jobs.
- The impact of Barnett Shale activities, for the State of Texas as a whole is estimated at $12.8 Billion in gross product per year and +/– 115,000 permanent jobs.
- The economic impact since 2001 (year of Barnett Shale benefits increased), are estimated at $110.7 Billion in gross product and +/– 993,600 employments.

Estimated Current Statewide Impact of Oil and Gas Exploration, Drilling, and Operations; Royalty and Lease Payments; and Pipeline Construction, Maintenance, and Operations in the Barnett Shale*

ECONOMIC BENEFITS (Monetary Values in Billions of Constant 2013 Dollars)

	Drilling	Royalties	Pipeline	TOTAL
Total Expenditures	$33.0	$1.4	$1.0	**$35.4**
Gross Product	$11.7	$0.7	$0.4	**$12.8**
Personal Income	$6.8	$0.4	$0.3	**$7.5**
Retail Sales	$2.7	$0.4	$0.1	**$3.3**
Employment (Permanent Jobs)	100,336	9,095	5,563	**114,994**
FISCAL BENEFITS (Monetary Values in Millions of Constant 2013 Dollars)				
Local Governments**	$460.1	$36.7	$20.4	**$517.3**
State of Texas**	$588.1	$72.5	$25.8	**$686.3**

SOURCE: The Perryman Group

* Totals may not add due to rounding.

** Includes fiscal effects stemming from activity outside the region identified by the Texas Railroad Commission.

Estimated Current Regional Impact of Oil and Gas Exploration, Drilling, and Operations; Royalty and Lease Payments; and Pipeline Construction, Maintenance, and Operations in the Barnett Shale*

ECONOMIC BENEFITS (Monetary Values in Billions of Constant 2013 Dollars)

	Drilling	Royalties	Pipeline	TOTAL
Total Expenditures	$29.7	$1.3	$0.9	**$31.9**
Gross Product	$10.8	$0.6	$0.4	**$11.8**
Personal Income	$6.3	$0.4	$0.3	**$7.0**
Retail Sales	$2.6	$0.4	$0.1	**$3.1**
Employment (Permanent Jobs)	93,871	8,506	5,279	**107,656**
FISCAL BENEFITS (Monetary Values in Millions of Constant 2013 Dollars)				
Local Governments	$427.0	$34.3	$19.4	**$480.6**
State of Texas	$551.8	$68.5	$24.4	**$644.7**

SOURCE: The Perryman Group

* Total Region includes Barnett Shale counties as defined by the Texas Railroad Commission including core counties of Denton, Johnson, Tarrant, and Wise and non-core counties of Archer, Bosque, Clay, Comanche, Cooke, Dallas, Eastland, Ellis, Erath, Hamilton, Hill, Hood, Jack, Montague, Palo Pinto, Parker, Shackelford, Somervell, Stephens, and Young. Coryell County was excluded due to lack of activity. Totals may not add due to rounding.

Environmental Issues and Regulations

- Studies and reports: VCOs have no impact on human health
- Influence of other pollutants in air quality
- TCEQ: Potential issues with VCOs and NGOs that could impact human health
- Increasement of citizen's complaints about impact of fracking activities on human health
- Since 2017: Texas regulations require fracking operators to complete and submit a list of chemicals used during the fracking process
- Cleanup programs by the Railroad Commission of Texas: The Oil and Gas Regulation and Cleanup Fund
- Lack of local regulations and multitude of actors