

Panel on Hydraulic Fracturing

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Context of Hydraulic Fracturing by Jack Irwin

To begin understanding hydraulic fracturing and its relationship to our class, this section aims to introduce what hydraulic fracturing technically is, the role water plays in hydraulic fracturing, and explain its overall connection to the water-energy nexus.

The Water-Energy Nexus

The interdependent relationship of energy and water requires examining energy production in terms of water usage and also water management in terms of energy usage.

“Energy is required to secure, distribute, treat, and deliver water. Conversely, water is used, consumed, and often degraded to develop, process, and deliver energy for production” (Scott et al. 2011).

It is important to distinguish water *used* in the process of energy production and water that is *consumed* in the process of energy production. Water that is *consumed* is water that can not be used again after its used for the purpose of energy production. Water that is *used* can actually be used again after the process of energy production. (U.S. DOE, 2014)

Defining and Unpacking Hydraulic Fracturing.

A general definition of hydraulic fracturing is injecting a mixture of sand, water, and chemicals underground to stimulate cracking in a layer of rock.

Hydraulic fracturing has been used in the past for a variety of purposes. According to Cooley & Donnelly (2014), hydraulic fracturing has been used to develop drinking water wells, dispose of waste, and optimize geothermally produced electricity. Today, hydraulic fracturing is largely enveloped in the context of natural gas and oil extraction. The first commercial use of hydraulic fracturing for this purpose took place in United States in the 1940s. Although, it weren't until the late 1980s when the larger economic potential of hydraulic fracturing was realized by George Mitchell who combined the practice with horizontal drilling in the state of Texas.

Now “unconventional” gas and oil that lay in the pores of shale rock formations thousands of meters below the surface has become accessible and profitable. This is not only an unconventional source of energy because of the sheer depth, but also because hydraulic fracturing is an unconventional process, which requires high-skilled labor across many fields. (Raimi, 2018)

Water's Role in Hydraulic Fracturing

Fracking fluid is a mix of chemicals, sand, and water. Generally 95% of it is sand and water, but the small percentage of chemicals is still objectively a lot considering the scale of the amount of water being injected. An enormous amount of fracking water goes into the ground: “In 2011 the EPA estimated each fracking event requires 2–4 million gallons of water. The EPA estimates 35,000 wells undergo fracking annually in the United States, requiring the amount of water consumed in a year by some 5 million people.” (Schmitt, 2011). Thus, roughly over a 100 billion gallons of fracking fluid is used annually.

Then we have to think of what happens when that fracking fluid is pumped out and still full of chemicals. It is then dealt with in one of three ways. Treating the water is costly and generally not a common method. In other cases, there's just a wastewater pit they make filled with flowback wastewater. However, most commonly the wastewater is put back deep underground (Scott, et al. 2015). Relating this to the water-energy nexus, it is clear that the majority of the water used in hydraulic fracturing is *consumed* rather than *used*.

Conclusion

Hydraulic Fracturing is a clear example of the water energy nexus and how we make a direct trade-off of water pumped for energy extracted. It's imperative to realize that furthering energy production has brought more produced water for more flexible water management strategies. However, in prioritizing energy we fail to see how water is ultimately degraded over the long run.

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Key issues

- Conflicting statistics → Check sources, research methods, who commissioned the studyⁱ
- Check economic impact analysis methods as this can misconstrue data to support either narrativeⁱⁱ
- Economic externalities not accounted for by drilling companies, reports

Pros	Cons
<p>High wage job growth</p> <ul style="list-style-type: none"> • Created 725,000 jobs associated with industry between 2005-2012 • As of 2015 870,000 direct jobs • Average 2% increase in employment in counties with wells and a \$1,700 increase in wages per capitaⁱⁱⁱ 	<p>Not consistent or secure jobs</p> <ul style="list-style-type: none"> • Construction for first week, productivity drops 60-80% within first year • Jobs are sporadic, and temporary • Peak number of jobs needed, not steady job growth from initial figures
<p>Reduction in energy costs</p> <ul style="list-style-type: none"> • Estimated \$100 billion in energy cost savings for 2014 • Energy prices however follow geopolitical issues, competition, and global supply and demand, more than reduced costs because of fracking • US produced energy means local energy supply cannot be threatened, stable costs 	<p>Economic Externalities</p> <ul style="list-style-type: none"> • Decreased agricultural output <ul style="list-style-type: none"> ○ Decreased irrigated crop’s productivity by 5.7% ○ Alberta lost approximately \$14.8 million in 2014, 11% of the average revenue earned from irrigated crop production. ^{iv}
<p>Boost to economy</p> <ul style="list-style-type: none"> • Potential tax revenue and local GDP contribution of \$2 billion/year/state • Royalties, increased traffic, incomes, can result in a modest local economic multiplier effect^v 	<ul style="list-style-type: none"> • Large water consumption, surface water contamination, decreases supply/use for other industries/individuals^{vi} • Geographic disparity in local environmental/water costs and private economic benefits^{vii}
<p>Revitalizing rural areas</p> <ul style="list-style-type: none"> • One million dollars of new production leads to \$61,000 at the county level and \$117,000 at the 100 mile level^{viii} • 70% of workers in the industry originate from other areas of the country, however they spend their money in county^{ix} • Royalty payments, can go towards paying debt, saving money 	<p>Overestimation in public economic benefit</p> <ul style="list-style-type: none"> • Modest increases overall in employment, wages, and household income^x • Estimated 20 years of recoverable shale natural gas → increase price future price • 4 year break-even on capital investment per/well^{xi}

Technology Improvements – Are investments to decrease costs/increase efficiency, means effort to ensure as much oil & gas extraction not increase compliance/safety beyond what is enforced

- Horizontal drilling introduced early 2000s, resulted in increased productivity but not prices as energy prices are influenced greater by geopolitics and threats to global supply/demand
- Array fracking – Improved drilling technology that drills multiple wells simultaneously, increased efficiency = more company profit, no expected job growth, less time needed at well site

- 1 (Kinnaman, 2011)
- 2 (Rousu, Ramsaran, & Furlano, 2015)
- 3 (Feyrer, Mansur, & Sacerdote, 2015)
- 4 (Farah, 2016)
- 5 (Weber, 2012)
- 6 (Mehany & Guggemos, 2015)
- 7 (Scott, et al., 2011)
- 8 (Feyrer, Mansur, & Sacerdote, 2015)
- 9 (Kinnaman, 2011)
- 10 (Weber, 2012)
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Social Effects of Hydraulic Fracturing by Lia Newman

The enormous public and academic controversy surrounding fracking derives from the many potential and known **social and health risks** associated with the practice. Temporal and spatial context is incredibly important when discussing social effects, as the costs associated with fracking are typically at the **local** level.

Water Quantity as a Local Issue

US National Context	-fracking uses less than one percent of water annually, but water used is lost to the water cycle ¹ -agricultural irrigation, thermoelectric power, aquaculture>>> fracking ² -fracking ~ conventional gas or oil extraction, through production has increased ³
Local Context	-over half of fracking operations in the US since 2011 have occurred in high or extremely high water stressed areas, and over 55% were in areas experiencing drought ⁴ -water usage can account for a large proportion of available water in communities -Dimmit County, Texas: 25% of water used towards fracking ⁵ -increases water competition challenges: agriculture vs municipal vs industry

Health Effects: Differing Camps

NO IMPACT	HARMFUL IMPACT
-2016 Report: EPA did not find evidence of “widespread, systemic impacts on drinking water” in US in its six-year study, but admits to research gaps ⁷ American Petroleum Institute backs EPA ⁸	-Physicians for Social Responsibility, Concerned Health Professionals of NY, Agency for Toxic Substances and Disease Registry, Science Advisory Board -Cases of groundwater and surface water contamination of drinking water wells have been reported
Definitional concern over “widespread” and “systemic”, impacts are at local level	Cases of groundwater and surface water contamination of drinking water wells have been reported ⁶

Known and Potential Health Effects

Regional	Respiratory, cardiovascular effects, stress
Local	Highest risk area, includes also nervous system impacts, birth defects, disorders, cancer, reproductive issues, mental health, stress of unknown effects and lack of transparency, noise and light pollution
Occupational Hazard	Additional exposure to silica sand, which can cause silicosis (lung disease). National Institute of Occupational Safety and Health issued a hazard alert after finding elevated levels of silica in air at fracking sites in multiple states. ⁹

Environmental Justice

Definition: defined by US EPA as “fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies” (US EPA: Environmental Justice).

-Fracking has a disproportionate impact on **poor, rural communities** in the US who are pressured by the industry to sell their land, more incentivized by economic profit, hold less power than their wealthier counterparts, and rarely reap the economic benefits.¹⁰

-**First Nations** living in NE BC affected, not fully consulted about developments on their traditional lands. Their Treaty 8 rights are not fully respected.

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The Politics of Hydraulic Fracturing by Shakti Ramkumar

The political dimensions of the fracking debate include (1) considerations of who creates **rules and regulations** around how and if fracking should proceed and (2) the relationship between increased fracked oil & gas production and **geopolitics and energy security**.

Fracking Governance: Who makes the rules?

Split jurisdiction and interests between federal and subnational governments

Many parts of the energy sector in Canada and US are federally regulated, while water is managed more regionally. Developing policy that considers the water-energy nexus and broader impacts of climate change requires **reconciling jurisdictional discrepancies** [1,2].

<p>National interests in fracking: Boosting national energy production for trade and energy independence, meeting national climate goals</p>	<p>Local interests in fracking: Creating jobs, revenue, protecting local ecosystems or property, health effects and displacement of people</p>
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Despite federal interests, **federal regulations for fracking are fairly loose** in the US and Canada:

USA: The oil and gas industry (including hydraulic fracturing) is exempt from 7 major US federal environmental laws, like the Clean Air Act and Safe Drinking Water Act, so regulation becomes the responsibility of states [3].

Canada: Federal regulatory authority and capacity was reduced when the federal government under Stephen Harper withdrew from the Kyoto Protocol, limited the Canadian Environmental Assessment Act, and reduced support for environmental research, leaving regulation to provinces [4].

Challenges of regulating hydraulic fracturing

- Regulatory gaps can occur when resource extraction outpaces the development of regulatory frameworks, due to rapid technological advancement and political pressure to meet energy consumption and energy security demands [5]
- Difficult to regulate on a federal level (unless it's an outright ban) because extraction potential, intensity, and social impacts are very site specific [8].
- Difficult to produce preemptive or agile institutional responses, due to limited historical data or peer-reviewed information to use in decision-making [9].

Political responses to fracking

Full ban or moratorium

This decision is often made based on a preventative principle (managing known risks), **precautionary principle** (managing uncertain risks), or strong public opposition [5].

e.g.: France, New York state, Maryland, Quebec, Nova Scotia

Permitted, with regulations that address fracking

This regulatory pathway includes legislation created to address fracking and its impacts specifically. Note that development of regulation is not necessarily evidence of compliance [4].

e.g.: Colorado, Alberta, EU (except post-Brexit Britain)

Permitted, using existing regulations with minimum revisions to address fracking-specific impacts

Many governments consider fracking to be adequately included within existing oil and gas regulations [6,4]. Revisions are often limited to disclosure of chemicals used in fracking. Disclosure requirements may be dependent on self-reporting, and may lack public transparency [7].

e.g.: Texas, Saskatchewan, Yukon [4]

Geopolitics and Energy Security

Proponents of increased fracked oil and gas production see energy independence from conventional oil rich countries as a primary benefit. For example, the US would be less reliant on Middle Eastern oil producers.

However, increasing shale resources have had uneven global effects: shale oil and gas oversupply also contributed to falling global gas prices (linked to trend of oil prices), which makes it harder for US and Canadian natural gas to compete on the global market [10].

Ultimately, decision-making and policies are driven by core values and priorities of a society with regards to climate change, the environment, climate justice, and democracy. *What are the similarities and differences in values on either side of the fracking debate?*

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Ecological Impacts of Hydraulic Fracturing

By Mihika Shetty

Water:

- **Ground water:** Studies on ground water contamination have proven to be inconclusive. However it is worth noting that the possibility exists for fracking fluid to leak into ground water either through well linings that have been compromised or where there isn't a secure natural Barrier. There are areas where fracking has been one of the cumulative causes for groundwater depletion along with irrigation for agriculture and this has led to draughts within the region.
- **Surface water:** There have been conclusive studies proving that surface is contaminated by not only fracking fluid but as well as sedimentation caused by construction and maintenance of fracking site. A study tracking trout in the Marcellus region found that high levels of mercury in the trout due to bioaccumulation from feeding on plankton and insects in the ecosystem.

Air: Natural Gas has been proven to be a better alternative for air pollution than Coal despite having a larger footprint. The extensive truck traffic that hauls materials for initial well development to waste removal contributes to ultrafine particulate matter and diesel emissions that have been recognised as carcinogens by the World Health Organization. In rural environments where most fracking takes place, there is a relative absence of air quality monitoring networks, because air pollution is generally seen to be a problem of urban environments and higher population densities.

Mitigation Efforts:

- **RAIN (River Alert Information Network):** The goal is to establish a multiple barrier approach for drinking water protection by integrating information from water treatment, source water protection and distribution system maintenance. The network implements these goals by installing monitoring equipment at appropriate locations and providing operational training. This includes providing information and tools to aid water suppliers in making decisions and improving communication between water suppliers about water-quality events
- **Green Completion:** Natural Gas is separated from waste water and placed in a pipeline to be sold.

Wild Life

- Sedimentation can disrupt aquatic ecosystems and habitats which in turn affects spawning for fish in the area
- Noise pollution can affect breeding and feeding for local wildlife

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Environmental Sustainability of Hydraulic Fracturing

by Adele Therias

Proponents of Hydraulic Fracturing present it as a crucial resource for the “transition to a clean energy future” (Furman & Stock, 2014). But how clean can fracking for natural gas really be? This section weighs the impacts of the “shale revolution” on water, GHG emissions, coal and renewable energy.

Hydraulic Fracturing: a Bridge to a Clean Energy Future?

Water Usage

> Fracking is highly water intensive, 8,000-80,000 m cubed (2-20 million gal) of water is used per well [2].

> Shale-Gas extraction and processing is less water intensive than other energy sources (coal is 2x more intensive, nuclear is 3x more intensive, oil is 10x more intensive and corn ethanol is 1000x more intensive) [4]. Proponents of shale gas also emphasize that it is less intensive than agriculture and thermoelectricity production in the United States, however the impacts of water shortage are usually felt at the local scale [4].

> 10-40% of the injected water returns as flowback (waste) and 95% of all wastewater produced from fracking in the US is injected underground, which can lead to high energy earthquakes [4]. However, technology innovation makes it increasingly possible to recycle wastewater [7].

> Extraction relies on the availability of water sources, which often occur in water-stressed regions and are predicted to become more variable due to climate change (Sovacool, 2014).

Emissions

> Natural gas is cleaner than oil or coal upon combustion: it generates lower carbon dioxide emissions per unit of energy produced [5].

> Emissions from production can be reduced with technological advancement (e.g. since 2012 the EPA requires “green completion” on all new fracking wells [4], which means using equipment that separates gas from the flowback water, and store the gas to prevent and/or reduce methane emissions) [1].

> Methane escapes during extraction and processing, including from pits of flowback water, through leaks in system, during flaring (Jackson et al., 2014) and 83% is emitted via intentional venting [7].

> The EPA estimates that leaks account for 0.2-1.5% of gross natural gas production while regional studies have found that number to reach 17% [4].

> Up to 16% of wells have spills every year, and between 2005 and 2014 there were 6648 spills reported across Colorado, New Mexico, North Dakota, and Pennsylvania [8]

> Cornell scientists estimate that emissions from shale gas will have an impact on climate change 130-200% greater than conventional natural gas due to its high methane content [10].

Alternative to Coal

> Shale gas provides an alternative to coal, which has significant environmental impact and CO2 emissions. “Historically, coal supplied almost half of the [US]’s electricity. Yet, as of April 2012, natural gas and coal were virtually tied, with each providing 32% of total generation.” (Parenteau & Barnes, 2013 in [10]).

> Greater use of shale gas in US is connected to increased coal combustion in other parts of the globe. For example, there was an increase in coal combustion in Europe between 2012-2013 because unused coal was exported from the US to Europe [6].

> Greater use of shale gas in US is connected to increased coal combustion in other parts of the globe due to exports [6].

Renewable Energy Sector

> Gas-fired power plants can quickly ramp up or ramp down to meet energy needs, which allows them to effectively complement fluctuations in renewable energy production [6].

> The high supply and lower price of previously inaccessible natural gas is predicted to lead to more energy usage, therefore higher emissions, and to undermine renewable sources of energy [4]. The success of shale gas has attracted investment away from renewables, for example in EU programme that funds research and innovation for natural gas [3].

> EIA predicts that natural gas plants will account for 63% of new electricity between 2014 and 2040, vs 31% for renewables, 3% for coal and 3% for nuclear [10].

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Bakken Formation-North Dakota by Eva Streitz

Summary

The Bakken Formation is located in North Dakota, Montana, Saskatchewan and Manitoba. My presentation focuses on impact of hydraulic fracking in North Dakota because it makes up about 91% of North Dakota's oil production. While conventional oil drilling began in the 1950s in North Dakota, the fracking oil boom began in 2007. Now there are over a thousand wells (Beacom, E., 2015).

Crude oil is the primary resource that is extracted by fracking in North Dakota, but natural gas is also increasingly being exported via pipelines. Natural gas is "bubbled up" in the process of extracting oil, and the practice of "flaring" or burning this extra gas is being cracked down on due to the environmental impacts. It has historically been treated as a waste product instead of a resource in North Dakota (Rassenfoss, S., 2016)

There are several Indigenous nations located on and near the Bakken Formation in North Dakota. The most central nation in the Bakken formation is referred to as the "MHA Nation: Mandan, Hidatsa and Arikara Nation" (Beacom, E., 2015).

Hydraulic Fracking in North Dakota: Do the Pros outweigh the Cons?

Cons

- *Flaring* is a common, and legal, practice in North Dakota whereby oil companies burn extra natural gas that is "bubbled up" when extracting oil. This process is harmful to the environment because it releases greenhouse gases, kills vegetation around the site, causes noise and light pollution, and releases soot into the environment (Beacom, E., 2015).
- Brine spills are common while transferring wastewater to disposal facilities (Dawson, 2015)
- There has been a rapid increase in population in Western North Dakota, specifically Williston, aka "Boomtown U.S.A". This increase has overwhelmed government operations such as law enforcement and social services. There is increased violence drugs and sexual abuse, and insufficient policing to control it. Traffic has increased, and the cost of living has risen in Williston (Dahle, T. O., & Archbold, C. A., 2015).
- The MHA Nation has suffered the loss of culture and home. They have been victims of "extractivism", whereby wealthy and powerful oil companies have coerced them into land leases. The MHA Nation has suffered the repercussions of an increased population growth, leading to increased crime rate, human trafficking, drug abuse, noise pollution, and traffic (Wolf Tice, 2016).
- Effects of fracking on groundwater in inconclusive and sparse. One study found

no effect on groundwater, but study was problematic (McMahon, P. B. et al., 2015).

Pros

- According to the Bureau of Labour Statistics, North Dakota has the 3rd lowest unemployment rate in the U.S., at 2.6% as of 2017.
- Obama's "All-of-the-Above" strategy- Revenue gained by fracking could encourage energy independence and be put towards green energy innovation (Steffy, 2016)
- There are an increasing number of 100% tribal-owned oil production companies in the Bakken region that are beneficial to the tribe because the royalty rate return is over 26% as opposed to the common 18% for outsider oil production. This also brings in more jobs for the tribe members, and in some cases there are degree programs offered to tribal members to be able to work in the oil industry (Wolf Tice, 2016).
- The MHA nation generates a certain amount of revenue from these companies that exist on their land. The individual compensation breaks down to \$1,000 in a bi-annual payment to tribal members over 21. (Wolf Tice, 2016).

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Case Study: Marcellus- Aini

Background info:

- Most extensive play: 14–25 million hectares, 4000-8000 ft in depth, 50-200 ft in thickness. [3]
- Higher population density and less remote than many other sites
- Range Resources struggled with the results by employing the method used at Barnett Shale, until a unique formula was developed for Marcellus. [3]
- New horizontal wells spudded per year. The Marcellus region went from 71 wells spudded in 2007 to 1,607 in 2013. Current trend complies with the prediction made in 2011, where 60,000 more wells are expected to be drilled before 2030. (Data from state agency) [7]

ECONOMICAL

- ❖ Export income [2]
- ❖ After Marcellus boom, increase in Penn natural gas production corresponds to decrease in gas price both state-wide and nationally. This is different from data from pre-bloom period. [5]
- ❖ Increases employment by 3-6% and wage by 8-12%, not just fracking-related employment. However, some are short-lived and correlation is somewhat weak, varies between different counties. [5]
- ❖ Boost local economy, which many locals residents welcome. [1]
- ❖ Uncertain future: short production history and declining production [3]
- ❖ Same as many other energy sectors, overestimation is very common. 30-40% of potential shale resources is not accessible due to regulations and geographical factors. [8]

ENVIRONMENTAL

Wastewater

- ❖ High level of naturally occurring radioactive elements, dissolves in fracking water
- ❖ 65 to 90% of the toxic fluid is never recovered in Pennsylvania
- ❖ In 2011, wastewater was treated at industrial treatment plants, but soon the additional cost of this brought the wastewater to the frack again to be reused.
- ❖ Reusing wastewater is concerning: low flowback volume, production of more toxic wastewater [10]
- ❖ 2010, Bradford County well blowout, releasing flowback water [1]
- ❖ Penn State residents associated with nasal and sinus, migraine headache, and fatigue symptoms [8]

Deforestation

- ❖ Pennsylvania was 84% forested prior to 2005 [6]

- ❖ Bradford: Destruction of core forest habitats: Between 2000 and 2012, hydraulic fracturing infrastructures took out 13,000 hectares of forest (4.3% of whole county). Horizontal structures (gathering lines and roads are the most detrimental, like slicing the land into pieces. [3,6,7]

SOCIAL

Underdeveloped policy

- ❖ Overtime, the state has restricted municipal/local government to regulate oil and gas development. [4]
- ❖ Many fracking activities are solely regulated by the state since they get exemptions from federal regulations.[4]
- ❖ Wastewater associated with development of natural gas are exempt from regulation. [4]
- ❖ Safe Drinking Water Act exempts “underground injection of fluids . . . pursuant to hydraulic fracturing operations related to oil, [and] gas”, leaving it to the state to establish minimum water standard, which is problematic. [4]
- ❖ Gas company violations, increasing in number (doubled even though the number of new wells increased slightly). [4]
- ❖ Penn Department of Env Protection fails its own standards, missing out on 55% of the new wells inspections in 2010. [4]
- ❖ Staff increase from 60 in 2010 to >200 in 2013, covered by increase in drilling permit fee [2]
- ❖ Drilling is not permitted within 500 ft of watercourse/building, within 1000 ft from major streams, private wells, etc. [2]

Farmer’s dilemma [1]

- ❖ Marginalized by the agriculture industry, it is hard for small/medium sized farmers to sustain their business.
- ❖ In order to sustain their business, and with pressure from gas companies, they sign out

lease that allows the company to access their land and mineral properties.

- ❖ “Devil’s Bargain” - constrained to depend on natural gas market for income, in order to secure their livelihood.
- ❖ However, many still did not get paid the royalty cheque. Also, they have no control over who access their land and when.

- ❖ Lack of transparency: what the gas company say and do is different.
- ❖ Lack of power: farmers bullied in decision-making process.
- ❖ Transition out of dairy farm - less labor intensive.

Citation:

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