State of the Fight against Fracking in America and its Environmental Effects in the Northeast and Gulf Coast

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Downsides to Oil and Natural Gas Production Technology

The United States is the world's largest oil and natural gas consumer, expending 919.7 million metric tons of oil and 29.95 trillion cubic feet of natural gas in 2018 (Garside, 2019). Both resources have multiple uses ranging from cooking, transportation, plastics to many other applications. With the discussion of their usage also arises the discussion concerning their production. There are many different methods for extracting these materials from the Earth, the most popular being hydraulic fracturing. Hydraulic fracturing was first used in the late 1980s and has dramatically increased in usage since the late 1990s onwards, allowing US energy companies to access previously unreachable deposits of shale gas/crude oil. This technique has resulted in the US becoming the largest producer of oil and natural gas in the world.

However, there may be more downsides to this widely-used technology. A New York Times article stated a fracking chemical, 2-Butoxyethanol, was found in 3 Pennsylvania households' drinking water. Testimony from Susan Brantley, a geoscientist from the University of Pennsylvania, states this is the first instance of organic compounds ending up in drinking water wells due to shale gas development (St. Fleur, 2015). The likely cause of this is that there was insufficient casing surrounding the drill, enabling wastewater to escape the well and be released into the surrounding rock layers. Additionally, in a separate analysis, a correlation was drawn between infant mortality and fracking activity in Pennsylvania (Busby & Mangano, 2017).

Due to the possible harmful effects, Majumdar (2019) states one would tend to believe hydraulic fracturing would be banned by all states or the regulation that encourages these reckless activities by energy companies would be repealed. However, the United States federal government itself has encouraged the practice's rise in popularity through the Halliburton Loophole, 2005 Energy Act. This loophole exempted the oil and gas industry and its injection of

fracking fluids into the ground from the Safe Drinking Water Act. Additionally, on the policy side of matters, lawmakers have had to deal with conflicts between their constituents and balancing both economic and social returns from the energy industry (Majumdar, 2019). This is even more difficult, for those elected officials that represent energy-dependent states.

Due to the aforementioned reasons, a case study analysis of the practice's consequences and a timeline that displays how the practice came into popularity supported by policy analysis and interviews will be the first step in fighting against this damaging practice. Therefore, this research will highlight hydraulic fracturing's environmental effects in the Northeast and Gulf Coast and uncover its current political state in the US.

Fracking's Rise and its Repercussions

To give some background to the topic, hydraulic fracturing, more commonly known as "fracking", is a drilling process where oil and gas companies shoot a mixture of water and chemicals at high pressure to fracture loose levels of shale rock. By fracturing the shale, a geological layer in the Earth's crust, companies are able to efficiently extract the natural gas/crude oil deposits that exist above the shale, while generating byproducts such as highly toxic wastewater and cracks in the rock layers.

The popularity of hydraulic fracturing has exploded in recent years, especially in the Marcellus shale region in the northeastern US. (Natural Gas Pipeline Certification: Policy Considerations for a Changing Industry, 2017). According to Murtazashvili and Piano (2019), this explosion was due to the optimal fracking water mixture discovered by George Mitchell and US energy companies realizing they would now be able to access difficult-to-reach natural gas/crude oil resources that they were not able to before. This allowed the United States to

greatly increase shale production compared to other countries (Murtazashvili & Piano, 2019). Moreover, with the exemption of the energy companies from the Safe Water Drinking Act that was mentioned previously, the federal government was able to overstep state governments and force them to deal with their legislation, usually loose restrictions put in place to remove fracking from federal oversight. Oil and gas-rich states that fracking gained strong momentum in, such as Texas and Wyoming, welcomed the regulation, while states that have discouraged the practice, such as New York and Florida, protested against it (Majumdar, 2019).

As the practice grew in prevalence, so did the opposition. It became common knowledge that hydraulic fracturing had a number of detrimental effects to the environment and humans. The first of which was the possibility of drinking water supplies being contaminated through groundwater due to dumping wastewater into disposal wells. As explained in Myers's paper (2012) that analyzes water movement in the Marcellus shale, fluids travel much quicker through areas that have already been "fracked" than "un-fracked" areas. This is supported by an analysis on the porousness of sandstone and shale by running mock scenarios with water flows (Myers, 2012). As groundwater supplies can be contaminated, so can surface water supplies. The paper written by Entrekin, Evans-White, Johnson and Hagenbuch (2011) analyzes possible paths wastewater could have traveled given the topography and the short distances to above-ground drinking supplies. The analysis also takes into account the welling sites of these energy companies and their corresponding proximities to public drinking wells. Thus, displaying how likely contamination can take place and complementing the findings in the New York Times article mentioned on Page 1 (Entrekin et al., 2011). The last danger of fracking is the unexpected seismic activity that results from the fractures in the rock layers. One analysis associates the rise in seismic activity in Oklahoma with the increase in hydraulic fracturing injection wells,

presenting a clear, causal relationship between the two variables (Bulgarelli, 2017). Given these deleterious consequences, anti-fracking sentiment began to steadily rise and grow.

However, Mazur says the harmful effects examined above weren't discussed within society until the movie, *Gasland,* directed by environmental activist Josh Fox, was released. It sparked discussions about regulating hydraulic fracturing/energy companies and mobilized the populace to take matters into their own hands (Mazur, 2018). Ladd's paper states the main points that encourage Floridians to take active action against energy companies are the protection of community health and the water supply, protection of the environment and peace between all parties involved in this societal conflict for the betterment of climate change and renewable energy sources (Ladd, 2018). If energy companies displayed more regard for these items, their actions would be received much more warmly. However, that is not the case. Thus, this research is an important concern as fracking's effects need to be explored to comprehend its political profile.

Application of Responsible Innovation and Technopolitics

The frameworks I plan on utilizing in this are *responsible innovation* and *technopolitics*. Technics refers to modern technology and methods while politics refers to the allocations of power associated with governing a country. The specific relationship between technics and politics can be defined as "inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships." (Winner, 1980, p.123). Going off the definition from Winner, fracking's relationship with politics can be considered an exploitation of US government power and authority. Policies supportive of fracking, such as the Halliburton loophole, are commonly backed by government officials from

fracking-heavy states that take money from oil and gas companies in exchange for them pushing their motives. Given this abuse of power, I will break down the public policies and how they are pushed to becoming legislation. I will also address the unintended consequences of fracking and how they are overlooked by corrupt politicians when they block policy meant to alleviate them.

Responsible innovation is a framework that desires to promote innovation that is socially beneficial and reduce macro-ethical failure as evidenced by, "As the limits of technical expertise become exhausted, there is a need to turn to developing additional competencies and broader skill sets to address the multitude of macro-ethical issues that arise throughout the engineering process." (Foley & Gibbs, 2019, p. 20). I will use responsible innovation because oil and gas companies fail to take into account the environmental and social consequences from their hydraulic fracturing processes that have led to unanticipated harmful effects. Through my research, I will explore how to apply the framework's System Thinking and Anticipation aspect to ensure alignment with hydraulic fracturing's design specifications. This is because companies have made minimal efforts to remediate the effects of wastewater, only treating the byproduct if it allows them to reuse it. Therefore, I can use this framework to innovate how companies can come up with better, more ethical ways to treat wastewater. Furthermore, I can use the framework to gather important points from constituents living in counties with hydraulic fracturing to help me pressure energy companies to reevaluate their extraction processes in order to promote social good. The institution of these methodologies would at least eliminate the harmful effects of wastewater contaminating drinking supplies/polluting ecosystems and take the first step in making fracking an entity that is not completely environmentally unfriendly.

To conclude, the primary frameworks I will use are *responsible innovation* and *technopolitics.* Technopolitics will focus on breaking down how malicious policies that promote

hydraulic fracturing become legislation due to the influence of oil and gas companies on lawmakers. Responsible innovation will focus on how oil and gas companies can modify their fracturing processes to promote social justice, build resilience and address existing macro-ethical issues.

Research Question and Methods

Through my research, I answered the question, What is the State of the Fight against Fracking in America and its Environmental Effects in the Northeast and Gulf Coast? I believe this is a topic in society that doesn't receive enough spotlight for the scale of the issues it causes.

The two methods I used to look into this topic are case study analysis and policy analysis supported by prior literature. I used specific examples where the populace claimed that energy companies had fallen short of holding up their promises to communities. I examined case studies from the Environmental Protection Agency (EPA) (2019) analyzing hydraulic fracturing in 2 locations in Pennsylvania and 1 in Texas. For each EPA case study, I took notes on why the specific area was investigated, what the findings were and how damaging the consequences were, if any. In addition to the case studies, I analyzed a study by Cornell University (2014) presented in a case study analysis by Greenpeace (Greenpeace, n.d.) on the amount of methane produced by the process and other studies regarding fracking's effects.

Policies encouraging companies to overstep boundaries also need to be examined to realize the root cause in fracking's rise. This includes the Halliburton Loophole which exempted oil and gas companies from the Safe Drinking Water Act (Brady & Crannell, 2012), thus removing them from federal oversight. I analyzed policies like the aforementioned that popularized fracking and researched how fracking itself encouraged the institution of those

policies. To complement both the analyses, I interviewed 5 constituents in counties located in Pennsylvania and Texas with fracturing activity to gain firsthand accounts of the practice's environmental implications and its political qualities. 4 out of the 5 constituents' occupations were newspaper editors as I believed they would be the most well-versed people to speak about the activities taking place within their community and the actions of their community's political figures.

Hydraulic Fracturing's Effects and Relationship

The political state of the fight against fracking in America is at a standstill. In regards to fracking's environmental effects in the Northeast and Gulf Coast region, it has been proven to be harmful for many reasons. The practice is linked to the contamination of drinking water, releases of methane gas and rises in seismic activity. Table 1, below, shows the questions and answers from the analysis conducted on the Environmental Protection Agency's case studies (2019) investigating specific counties within Pennsylvania and Texas. All 3 areas were investigated on reports of contaminated drinking water and samples were taken from a variety of wells and bodies of water (Environmental Protection Agency, 2015).

	Southwestern Pennsylvania	**Northeastern Pennsylvania**	**Wise County, Texas**
What are the specific areas investigated?	- 2 regions within Washington county near the townships of Amwell, Cross Creek, Hopewell and Mount Pleasant	- 3 regions, 2 of the regions in Bradford county and 1 in Susquehanna county	- 3 regions within Wise county
Why was the specific area investigated?	-Reports of contaminated drinking water where hydraulic fracturing occurs	-Reports of contaminated drinking water where hydraulic fracturing occurs	-Reports of contaminated drinking water where hydraulic fracturing occurs
What is the procedure of investigation?	- 3 rounds of water sampling: July 2011, March 2012 and May 2013	- 3 rounds of water sampling: October/November 2011, April/May 2012 and May 2013	- 5 rounds of water sampling: September 2011, March 2012, September 2012, December 2012 and May 2013
How many samples/experiments were taken?	- 16 domestic wells, 3 springs and 3 surface water locations	- 36 homeowner wells, 2 springs, 1 pond and 1 stream	- 16 domestic wells, 3 production wells and 4 surface water bodies

What is the depth of the water sample sites?	- Depth of the water sample wells ranged from 50-160 feet	- Deepest of the water sample wells was 440 feet	- Noted depth of one of the domestic wells is 300 feet
What are the water samples being tested to find?	- Contamination of shallow ground water by stray gases (methane) - Fracturing chemicals associated with unconventional gas development - Deep formation waters (brine)	- Contamination of shallow ground water by stray gases (methane) - Fracturing chemicals associated with unconventional gas development - Deep formation waters (brine)	- Contamination of shallow ground water by stray gases (methane) - Fracturing chemicals associated with unconventional gas development - Deep formation waters (brine)
What is the methodology of the analysis?	- Visual observations about water were made - Analyzed water for dissolved gases, acids and isotopes - Used water quality trends to determine correlation	- Visual observations about water were made - Analyzed water for dissolved gases, acids and isotopes - Used water quality trends to determine correlation	- Visual observations about water were made - Analyzed water for dissolved gases, acids and isotopes - Used water quality trends to determine correlation
What were the key findings?	- Primary MCL (Maximum Contaminant Level) in Nitrate and Lead levels - Secondary MCL in Iron and Manganese, Aluminum levels - Elevated Chloride levels, secondary MCL	- Primary MCL in Barium, and Combined Ra-226 + Ra-228 - Secondary MCL in Sulfate, Iron and/or Manganese, Chloride and TDS - High Chloride and TS levels for surface water	- Secondary MCL in Chloride, Iron and Manganese - Elevated concentrations in Specific Conductivity, Calcium, Potassium, Magnesium, Sodium, Bromide, Iodide, Strontium and Barium
What were the study's limitations?	- No pre-drilling baseline to compare the statistics to - No access to fracturing sites for sampling and closer examination	- No pre-drilling baseline to compare the statistics to - No access to fracturing sites for sampling and closer examination	- No access to fracturing sites for sampling and closer examination
Any other notable matters?	- Plan for closure and reclamation of the impoundment site was submitted to the Pennsylvania Department of Environmental Protection in February 2014	- Nothing significant to note	- Chloride was detected in two study wells at concentrations that exceeded the chloride Secondary MCL by a factor of 2.2 to 7.9 times - Was not able to determine whether potential source of third impacted well was brine or landfill leachate due to lack of available site-specific data

Table 1. Findings from the case studies conducted by the Environmental Protection Agency. (Created by Umesh, 2020)

Beginning in the northeastern US, the key findings of the Environmental Protection Agency's southwestern Pennsylvania case study (2015) related to fracturing were the levels of iron, manganese and chloride. It was noted the iron and manganese could have come from natural sources, but there is a slight possibility that the elevated levels could have resulted from fracking. Unfortunately, that could not be conclusively proven. However, it is stated with confidence that the elevated concentrations of chloride are most likely linked to sources associated with the Yeager impoundment site, an open-air storage "pool" where wastewater from

nearby wells is stored and off-gas until reuse or transport. Once this case study was released, a plan for closure and reclamation of the impoundment site was submitted to the Pennsylvania Department of Environmental Protection in February 2014, suggesting potential suspicious behavior from the energy company operating it (Environmental Protection Agency, 2015).

The findings of the EPA's northeastern Pennsylvania case study (2015) related to fracturing were the levels of dissolved methane, chloride and TDS. From these findings, it is possible to say the elevated levels of chloride and TDS could be attributed to a fracturing well pad's activities. Again, there is a cloud of doubt surrounding the finding, but there still is a possibility it came from fracturing. The same goes for dissolved methane as it has long been associated as a naturally-occurring, stray gas that comes with oil and gas exploration - so not much can be said to whether its level intensified due to fracturing (Environmental Protection Agency, 2015).

Furthermore, Caulton (2014) stated that in June 2012, seven well pads determined to be in the drilling phase in southwestern Pennsylvania were noticed to be emitting 34 grams of methane a second. The danger this methane emission poses in terms of being both a household risk and global threat is massive. As a household risk, the paper written by Osborn, Vengosh, Warner and Jackson (2011) explains the average methane concentration in drinking-water wells in active gas-extraction areas in northeastern Pennsylvania and upstate New York was 19.2 mg CH_4 L^{-1}. That level itself is a major hazard for a potential explosion, while dissolved methane samples from the same area away from active gas-extraction areas averaged 1.1 mg CH_4 L^{-1} (Osborn, Vengosh, Warner, et al., 2011). As a global threat, a Wall Street Journal article (2018) about methane leakage stated that the US energy industry leaks 2.3% of all the gas it produces directly into the atmosphere. Therefore, contributing to climate change as methane traps heat in

the atmosphere for 20 years until it dissipates, in turn raising the global temperature (Puko, 2018).

Firsthand Accounts from Fracturing

Table 2, below, displays questions and answers asked to constituents of Susquehanna county in Pennsylvania. From their answers, it is clear that the interviewees have not come in direct contact with the effects of the practice directly to their knowledge. However, Ms. Eldred (personal communication, February 26, 2020) and Ms. Wilson (personal communication, February 28, 2020) had stories to tell such as families finding elevated levels of methane in their drinking water in 2007/2008, or personal stories such as Ms. Eldred living upstream from a fracking site, hearing the creek in her backyard overflow from a gully, then learning that the same site had violated wastewater dumping standards the day before she was interviewed for this study. Ms. Eldred and Ms. Wilson had information on which energy companies were in the area - one such includes Cabot Oil and Gas. Cabot is a large player in the area and was fined $99,000 in 2017 for releasing too much natural gas into the air at numerous sites (Blanchard, 2017). Adding to the methane emission issue, Ms. Wilson stated that the energy companies still "flare off" the produced methane, meaning they burn it.

Transitioning to the Gulf Coast - the findings of the EPA's Wise county, Texas case study (2015) examined the levels of chloride and impact of brines and/or landfill leachate. The chloride concentrations at 2 of the study wells exceeded the chloride Secondary MCL by a factor of 2.2 to 7.9 times. Formation brines were also found to have impacted the two of the study wells, while for the third study well brines and landfill leachate were potential contaminants (Environmental Protection Agency, 2015).

	Pennsylvania 1	Pennsylvania 2
1. Name and County?	- Penny Eldred - Residing in Susquehanna county	- Stacy Wilson - Residing in Susquehanna county
2. When did hydraulic fracturing first begin in your community?	- Cannot remember exactly, but about 12 years ago	- Somewhere between 2007-2009
3. What companies are in your area? What are they drilling for?	- Cabot - Drilling for natural gas	- Cabot; Southwestern; Chesapeake; Chief; Talisman; Drilling for natural gas
4. How have you/your life been affected by the introduction of hydraulic fracturing?	- Trucks are ruining the roads in the town - Usually have lots of trucks during the initial stages of drilling	- Little more traffic with trucks
5. How has the environment around you been affected by hydraulic fracturing?	- Trucks hauling the wastewater around the clock causing bad roads	- No change in the environment - Department of Environmental Protection have done a number of publicized air quality studies
6. What would you say, in your own words, is the majority sentiment about the practice in your area?	- People are torn 50-50 - Some argue that it has helped the economy while others are concerned about the long-term environmental effects	- In Susquehanna county, the majority of the people look favorably upon the industry - The general nature of the community is very skeptical with questions such as, “How long will it last? And “Will it end up lasting?”
7. What are your representatives’ take on the practice/what are they doing about it?	- Spoken with country commissioner and representative, Fred Keller - They widen the roads and watch the environment closely - Daily reports on violations by the energy companies	- Representative Fred Keller came in last year - Very pro-industry and interested in it as he came from an area where drilling has taken place
8. Do you think your representatives’ policies caused hydraulic fracturing to emerge in your community? Why?	- Not that she (Penny) is aware of	- Not to her knowledge - People knew hydraulic fracturing was coming and representative at the time, Chris Carney, may have encouraged its rise
9. Anything else you would like to add?	- Energy companies have contributed to the economy, built hospitals and invested parks - Penny herself is very torn as the companies utilize the town’s services, but she is also concerned about the environment - Strange experience in Summer 2017/2018, heard creek overflowing in backyard and she lives upstream of a fracking site - Viewed map of violated fracking sites on Feb 25th and the one upstream from her was one of the violated - Noted that the practice has contributed to a methamphetamine epidemic in the community as workers use the drug to stay energized while working	- Industry came to the area and began to foster relationships with different business - The energy companies do a lot of community work such as transforming the old, outdated clinic into a new hospital with the help of fundraising efforts - Energy companies support scholarship and educational projects - Portion of the wells are fracked with recycled water and there are no injection wells in Susquehanna county - In 2007/2008, homeowners noticed changes to drinking water, was investigated and found elevated levels of methane - People do not mind the practice because it has helped support the area after fall of dairy farming - “Public policy will never keep up with technology” - Companies used to flare the well and burn off excess methane but now harness the methane - Believes many in the area have been brainwashed by the injection well and recycling technique news

Table 2. Interviews from residents of Susquehanna county, Pennsylvania. (Created by Umesh, 2020)

Table 3, below, displays questions and answers asked to constituents of Wilson, Atascosa and Midland county in Texas. From their responses, it seems that all of fracturing's possible effects have been felt. In Ms. Kilbey-Smith's account (personal communication, March 5, 2020), Wilson county has experienced air quality issues due to flaring. In Ms. Pesqueda's account (personal communication, March 5, 2020), Atascosa county has experienced brown, dirty drinking water and an uptick in seismic activity in the past decade. Midland county has also experienced seismic activity and studies conducted in the region, according to Mr. Doreen (personal communication, March 5, 2020), have pointed to an increase.

	Texas 1	Texas 2	Texas 3
1. Name and County?	- Nannette Kilbey-Smith - Residing in Wilson county	- Rebecca Pesqueda - Residing in Atascosa county	- Stewart Doreen - Residing in Midland county
2. When did hydraulic fracturing first begin in your community?	- It has been around for a number of years	- Been around for a long time, could not remember	- Honestly cannot remember, fracturing has been around for more than a decade
3. What companies are in your area? What are they drilling for?	- Very unsure, most of the activity was southwest of Wilson county in Atascosa county - Drilling for crude oil and natural gas	- Fracpick and Halliburton, among others - Drilling for crude oil and natural gas, mostly crude oil	- Everyone drills in this area as it is the heart of oil boom - Drilling for crude oil and natural gas
4. How have you/your life been affected by the introduction of hydraulic fracturing?	- There has been an increase in heavy truck traffic carrying equipment - Trucks have directly impacted the safety in the community for young drivers - Trucks have impacted the quality of the roads	- Caused a lot of heavy traffic flow with a lot of trucks going back and forth - Economy goes up and down a lot	- More jobs have been created - As long as oil has been coming out of the ground, the economy has been thriving
5. How has the environment around you been affected by hydraulic fracturing?	- "Always have experienced seismic activity" since before the introduction of fracking - People have complained of air quality issues in proximity to active well sites in regards to flaring - Personally has not noticed anything	- Water issues in Charlotte, Texas in Atascosa county, there are a lot of drilling buildups in pipes and the water comes out rusty and dirty - Everyone deals with brown and dirty water - People have raised concerns about it, Rebecca herself is writing a story about it - One woman tried to wash her house and the water stained the sides of her house - Earthquakes and tremors have taken place in the area, enough to the point where people have felt them	- Do not know of any impact, no studies have said there are any dangerous conditions connected to fracturing around the wells - Seismic activity can be attributed to the disposal wells - There is some seismic activity in the region but statistics point to an increase - No reports of water being compromised

		- Seismic activity has intensified in the frequency in the past 10 years	
6. What would you say, in your own words, is the majority sentiment about the practice in your area?	- Wilson county has had many businesses open up headquarters in the area so it is supported - Carnes and Atascosa county appreciated the economic impact on the community, but are now reaping the other effects in terms of ecological and atmospheric impact - Other parts of the community do not care about the economic impact because they have not been affected by it directly in quality of life	- 50-50, many understand the impact and the drilling and fracking - Populace agree it is great for the economy, but are still concerned about the ecological impacts	- Many people support it as it is being done responsibly and is having a benefit to the city of Midland's economy, county and region - Those in government opposed to haven't done enough research and are not taking note of what it does and are scaring people with all the possibilities
7. What are your representatives' take on the practice/what are they doing about it?	- Government has been watching and working with these companies, but personally did not want to put words in the mouth of representatives - Have received economic recompensation regarding the damaged roads	- No idea as to what the representatives are doing	- They carry the same attitude as the populace, support the practice - They represent one of the 3 largest oil patches in the world, so the representatives spend a lot of time separating fact from fiction about the oil industry to those who oppose it in Washington
8. Do you think your representatives' policies caused hydraulic fracturing to emerge in your community? Why?	- Had not heard anything or done any research in that regard	- Congressman helps funds the activities to increase numbers of jobs - Fracking was going to appear in the community regardless - Difficult to say that former politicians have helped it take place because it was going to happen one way or another	- Do not think any policies caused the rise of it as it was going to happen regardless but does not know for sure about representatives' policies - But if given the opportunity, representatives would have definitely taken - Representatives would argue that nation has become more self-sufficient if other representatives came out with bans
9. Anything else you would like to add?	- Nothing else to add	- Nothing else to add	- There is no county in America, at least in lower 48, where oil production takes place and there are no earthquakes - Oklahoma's seismic activity is mostly caused by their injection wells and fault lines (due to studies) - Central Oklahoma's seismic activity is West Texas's activity multiplied by a factor of 100 - Do not personally know the difference in injection wells between Oklahoma, Eagle Ford area and Midland/Permian Basin area - Pecos has a large amount of seismic activity for Texas Texas law states that people have the right for certain drilling

Table 3. Interviews from residents of counties in Texas. (Created by Umesh, 2020)

An important point I noticed was that seismic activity surrounding the practice appeared heavily in Texas and not much in Pennsylvania. After learning there are no injection wells in Susquehanna county from Ms. Wilson and how there are injection wells in Texas from Mr. Doreen's accounts, I believe injection wells are the main causes of the fracking earthquakes. My belief is supported in this study by Fasola, Brudzinski, Skoumal, Langenkamp, Currie and Smart (2019), which shows that Eagle Ford shale play earthquakes are correlated with hydraulic fracturing activity through injection wells, and in Figure 1's graphs.

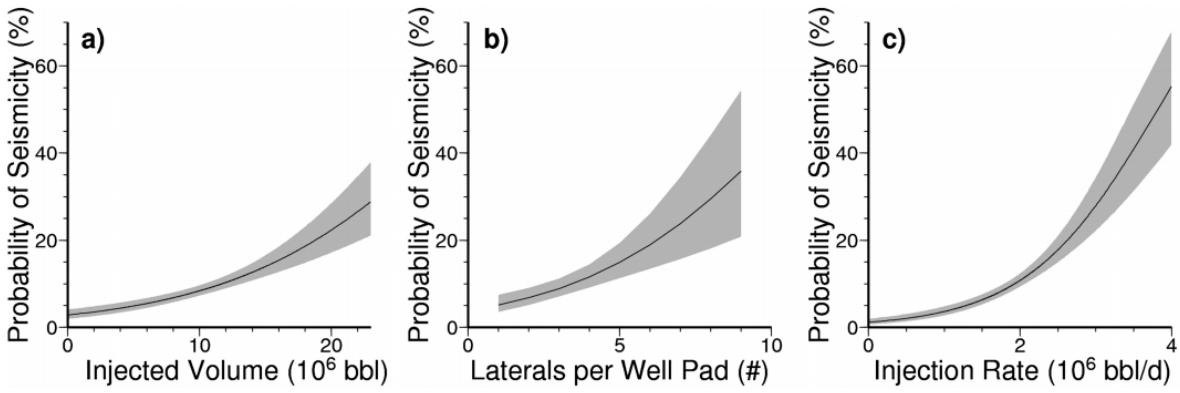

Figure 1. Probability of Seismicity based off of Injected Volume, Laterals per Well Pad and Injection Rate (Fasola et al., 2019)

Switching focus to the political side of the matter, the current sentiment about the practice in Pennsylvania is torn and lifeless. In Pennsylvania, from Table 2, both Ms. Eldred and Ms. Wilson stated that the practice was looked upon favorably due to growth in the local economy and the energy companies building a new hospital and parks. In my opinion, this seemed like energy companies were doing this to cover up their activities to the public.

However, people were also beginning to ask about the long-term effects of the practice, given the stories they were hearing about others in the area. When I spoke to them about their representatives' actions, Ms. Eldred and Ms. Wilson both had limited knowledge. This disconnect implied a sort of reluctance towards addressing the issue. The constituents seemed like they didn't care about the effects unless they were directly affected by it. Ms. Eldred has personally been affected by wastewater dumping and has heard about a potential methamphetamine drug problem the practice might have stirred up in the community, evidenced in Table 2. She voices her claims to the county commissioners and representatives, but does not follow up any more than that.

In Texas, the sentiment echoed around the same 50-50 disagreement from the Pennsylvania community. Many people support the business the practice brought, but are concerned about the environmental impacts. However, the pushback against the practice here is not as widespread compared to Pennsylvania due to the massive support it has throughout the state and from representatives. In Midland county, Mr. Doreen said the populace believes those that oppose the practice have not done the research about its economic effects and are scared away by the possibilities.

Hydraulic fracturing's rise in these two states can be attributed to specific policies that allowed it to enter the states in the first place. I learned that federal policies put in place to discourage the rise of fracking have been nullified for the intentions of state governments (Brady & Crannell, 2012). The state government is able to override federal legislation through the Commerce clause in the US Constitution which gives states power to regulate interstate commerce. Through this, the oil and gas industry and the practice of hydraulic fracturing are exempt from the Safe Drinking Water Act (SWDA), the Resource Conservation and Recovery

Act and many others (Brady & Crannell, 2012). By receiving exemption from these statutes, the energy industry's activities are not held to any sort of standard. As I analyzed the Safe Water Drinking Act, I learned it was supposed to include hydraulic fracturing under federal oversight in accordance with the U.S. Court of Appeals for the 11th Circuit's ruling. However, it was removed after the EPA conducted a shoddy study and declared the practice to pose "little to no threat to [underground sources of drinking water]" (Brady & Crannell, 2012, p. 44). I noticed some strings had to be pulled during this because it seemed almost as if the EPA wanted hydraulic fracturing removed from federal oversight. I infer that oil companies encouraged legislators from states that could benefit from fracking to push the EPA into falsifying the study, removing the practice from oversight in exchange for money or other incentives.

This change to the SWDA was the Halliburton Loophole. As I analyzed that policy, I learned 2 bills were proposed in 2005 and 2009 to amend the loophole. However, they were blocked by Congress, presumably by representatives whose states' economies were boosted by the practice. To back these claims, Pennsylvania has passed pro-fracking policies such as a bill that prohibits local jurisdictions from banning hydraulic fracturing activities (Brady & Crannell, 2012). In Texas, Davis (2012) stated the combination of a large, conservative Republican legislature operating with 2 past Republican governors and most monitoring of energy activity placed under the oil and gas-favoring Texas Railroad Commission, has allowed hydraulic fracturing to thrive with no resistance. By examining the policies put in place and those who backed the policies in Pennsylvania and Texas, it is clear to see how fracking became what it is now.

Looking over the cases and the interview accounts, the constituents' personal accounts are backed up by the findings from the cases and studies. Ms. Wilson's and Ms. Pesqueda's

accounts of their community having to deal with dirty, contaminated water go hand in hand with contaminants being found in southwestern Pennsylvania's water wells. (Environmental Protection Agency, 2015). Ms. Pesqueda's account about increased seismic activity also goes hand in hand with the Eagle Ford earthquake study's findings (Fasola et al., 2019). Furthermore, Ms. Wilson's and Ms. Kilbey-Smith's accounts of wells being flared off complement the Wall Street Journal article (2018) detailing the amount of methane leaked into the atmosphere and its effects. Although Ms. Kilbey-Smith and Mr. Doreen disagreed with water contamination and earthquakes being present within their communities, it is easy to see that some of the claims about hydraulic fracturing's social and environmental effects are well-founded.

Discussion

Evaluating the evidence above with respect to the *responsible innovation* framework, it is easy to see the widespread macro-ethical failure in each piece of evidence presented and the fact that companies are doing nothing unless prompted by the government or public. To minimize failure through the framework's System Thinking and Anticipation aspect, energy companies need to research wastewater recycling methods that will treat the water to a point where it can be disposed safely or harmlessly reused. Companies everywhere need better monitoring of their methane emissions and should engineer a technology that will harness this gas for alternative use instead of releasing it into the atmosphere. Lastly, the practice of injection wells should be discontinued given the link between the wells and earthquakes.

Energy companies must realize their "innovative" practice hurts real people and has terrible consequences, but can be used for social good if the aforementioned changes are implemented. With Texas politicians supporting the technology's operation within their state, the

technopolitics framework is heavily supported as fracturing is very compatible in the relationship between politicians and oil companies. Policies put in place by state governments and politicians such as the Pennsylvania representative, Chris Carney from Table 2, who supported the energy company's usage of the technology after it was exempted by the EPA, establish the relationships that are built upon the ability of this technology. Representatives in Texas might use their support of the technology to fund their campaigns and increase their chances of reelection. By turning a blind eye to the practice's effects and blocking legislation that is supposed to amend the technology's effect such as the FRAC act, unintended consequences such as seismic activity and methamphetamine epidemics are inflicted upon the general populace. Therefore, politicians need to be cognizant of the relationship they maintain with oil companies and begin using the technology for social good, beginning with placing the technology and oil companies that operate it under federal oversight.

Limitations present in this study, especially in the EPA case studies, were the lack of water sample information from before drilling entered the affected regions and from drilling sites themselves. This information would have helped my study as I would have had a better understanding of the region's water trends and it would've helped me see if certain mineral levels associated with the practice were affected. Additionally, drilling site-specific data would have been helpful as concentrations of potential contaminants would likely be the highest at the site itself. That data would hopefully sit in line with the inferenced trend of contaminant amount increasing as the water sample's proximity to drilling site decreases. A limitation to the political side of the study was that the interviewees were not as well-informed about the subject as I expected. I had incorrectly assumed interviewing those who are most likely to be directly affected by the practice would have the most to say about it. My findings seemed to be in line

with my background research from Boudet, Zanocco, Howe and Clarke's report (2018), which stated the indifference in opinion of those who lived close to the drilling sites.

What I would do differently in the future, in terms of who I interview, would be to get in touch with people who are somewhat geographically distanced from the drilling sites in hopes of finding fervent constituents who feel strongly about the issue. Those people would be a much better gauge for public opinion than the people I interviewed. I would also do a deeper search through the campaign donations for political candidates, current and past, exchanging favors for donations. I went through donations for some politicians this year but my efforts were unfruitful. In terms of the environmental effects, I would delve deeper into how injection wells cause seismic activity and apply the same concepts to see if drinking water is contaminated in the same manner. I would also contact oil companies to learn about what steps they are taking to minimize the practice's effects and later evaluate how effective those steps are.

I will use this research to advance my engineering practice by coming up with solutions that address the social inefficiencies through the *responsible innovation* framework. With the help of other engineers, I can develop technologies that will promote the better functioning of this technology within society and reduce overall macro-ethical failure. This research will aid in me advancing my ethical engineering practice through the *technopolitics* framework. The unethical political relationships explained previously will encourage me to become a more pro-active citizen and take a stand against the system this practice has arose through. By incorporating these frameworks in my thinking going forward, I can practice ethical engineering at a level that will guarantee the greatest benefit to society.

Conclusion

Overall, fracking's effects will soon come to light, backed by solid evidence and connections. Even though there is much controversy surrounding the practice, new reports are released every day gradually proving its harmfulness. Hydraulic fracturing is a harmful practice and action needs to be taken to remediate its effects. That action can come from politicians who have the power to regulate this practice, petroleum engineers who have the power to engineer the practice for social and environmental good and from the general populace who have the power to collectively bring about change in their community. At the end of the day, residents are constantly affected by this practice and it is our duty as engineers to do the best we can to keep them away from this technology's harm, while maximizing the technology's benefits.

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