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Reader's Guide to Fossil Fuel Dependency and Hydraulic Fracturing

Imagine the thrill of buying and owning your first new home. All your possessions are moved in and setup in a manner suited specifically to your own desires. You've worked hard these past few years, putting in extra hours and more effort than the average employee. It's been an arduous journey but it's finally paying off because now you are in a comfortable finical position with your savings, and you were able to buy that house you've always dreamed of being in. You are finally able to have your own garden, a hobby you've always enjoyed. This must be how the so-called American dream starts for most people.

Four years later, after countless new memories in your new home, a set of events occurs that will change your life forever. A company with new ground-breaking methods and advancements in technology have set their eyes on land that is merely hundreds of feet away from your property. They look at your surroundings with economical eyes, they know they can profit from working in this area and nothing is stopping them. At first you don't realize the new reality that is unfolding before your eyes but, soon enough your garden and backyard view are overtaken with the sights of machinery, pipes, and tanks. Work is constantly being done on this area now. The ever-present drilling harvests the products deep under the Earth right next to your home. Almost as soon as the drilling began, your health has been declining. Nausea, nosebleeds, and headaches are a constant burden that make you dream of the time when you first bought your home, and the machinery and work was not the sole focus of the view behind your backyard fence. If you had known this outcome, you never would have bought this house. The time you spent building your savings to buy the home were not worth it. The investment you made to purchase the house is diminishing. Your property and home are now only worth a fraction of the purchase price just four years ago. Some of your neighbours went into foreclosure, and with your health declining you may not be far behind them. You are slowly losing everything, while the company just hundreds of feet away is gaining it all. Nothing is preventing them from continuing the work here and spreading to new areas around the country.

Unfortunately, this story is not a work of fiction. This was Veronica Kronvall's reality. In 2007 she purchased her first home in North Texas. At the time it could be argued that northern Texas was the, "pumping heart of the oil and gas industry" (Goldenberg). An energy company actually drilled five wells behind her home just four years after she originally purchased it. Two of the wells were just 300 feet away from her idealistic garden. She did in fact experience nosebleeds, nausea, and headaches shortly after the drilling began. "Her home lost nearly a quarter of its value and some of her neighbours went into foreclosure. 'It turned a peaceful little life into a bit of a nightmare'"(Goldenburg). This nightmare of a situation was directly correlated to the process of hydraulic fracturing, or fracking as it is known in short. Veronica Kronvall is not alone though; countless other people would have nightmares of their own from hydraulic fracturing.

Sources of energy and its production, besides natural human and animal capabilities have always intrigued humans and have been sought after. A relationship between man and these sources can be traced back to early civilizations and has led to the modern technological era we are familiar with. Multiple different sources of energies have been discovered and used to develop human potential through innovation, which can be said to be our greatest tool. In current times this need for energy and power has increased rapidly to support our standards of living which are heavily reliant on these energy sources. However, the source of this energy is being is being used unsustainably. Today, our main source of energy that we rely on is derived from fossil fuels. To being our quest to explain hydraulic fracturing an understanding of what fossil fuels are, and the history of them is required.

Hidden deep below the Earth's surface lay ancient remains of previous life forms. Millions of years worth of vegetation, animal matter, and marine life are buried below the surface, trapped at depths once thought unobtainable by humans. Natural processes converted this organic matter into rock consisting mainly of hydrocarbon. Hydrocarbons are essential ever since man has learned that this organic matter can be burned for fuel. This organic material composed of hydrocarbons is found in the form of fossils, which is why we name this source of energy fossil fuels. These fuels were formed, "some 286 to 300 million years ago in the Carboniferous Period, which predated the dinosaurs and is part of thre Paleozoic Era" (Prud'Homme pg. 9). The naming of the Carboniferous period hints at the importance to man and its current relationship with fossil fuels. The root word, carbon, is the foundation of all fossil fuels. The Carboniferous Period was a time when the Earth was mainly covered by, "trees, large leafy plants, and ferns, and its water bodies were rich with algae, a common phytoplankton" (Prud'Homme pg. 9). During this period, Earth would be unrecognizable to us. It was covered by vast large-scale swamps. Essentially, at this time period in Earth's history the sources of most of the fossil fuels were still alive and active.

Throughout time these organisms, plants and animals, died off as is the natural cycle of things. Their remains ended up on the surface of the Earth, which forms a layer of organic matter called peat. As time continues, the peat is desiccated by compression and continually buried and transformed into rock. Earth's geological pressures and heat converted some of this rock into fossil fuels. These fossil fuels are exactly what humans drill deep into the Earth today to recover in order to convert it into energy. It is important to note that fossil fuels are unrenewable sources of energy, unlike wind, water, and solar energy which is renewable. In reality, there is a fixed amount of fossil fuels available for humans to use as energy sources and once burned are gone forever. It is critical for the reader to understand that harvesting and burning these fuels, “creates pollution, including greenhouse gases such as Carbon Dioxide” (Prud’Homme pg.10) and that these fuels are the primary source of energy today. These greenhouse gases lead to global warming as a result in the increase of the greenhouse effect, which is defined as,” The transmission of short-waved solar radiation by the atmosphere coupled with the selective absorption of longer-wavelength terrestrial radiation, especially by water vapor and carbon dioxide, resulting in the warming of the atmosphere” (Lutgens & Tarbuck pg. 561). Basically, these greenhouse gases create a layer of gas in the atmosphere that traps heat in the form of sunlight and increase the overall global temperature of the Earth.

There are many different types of fossil fuels. Hydraulic fracturing does not involve mining for all of these types; it is important to understand most of them before we focus on the fuels hydraulic fracturing is concerned with. The dependency on each of these energy sources has resulted in the relationship we have today with energy sources, and eventually pushed forward the need to develop energy harvesting technologies like hydraulic fracturing.

Coal is, “ a sedimentary rock consisting primarily of organic matter, formed in stages from accumulations of large quantities of undecayed plant matter. Used as a fossil fuel” (Lutgens & Tarbuck pg. 558). It is one of the primary fossil fuels produced in the United States as it is plentiful and relatively cheap. There are four main types of coal, classified by the type and amount of carbon present as well as the amount of energy and heat they produce when burned.

Anthracite coal is a rare type of coal found in United States, specifically only in Pennsylvania. “It is the hardest coal, and has a high carbon content (87-97%) that provides more energy than other coals" (Prud'Homme pg. 11). It is thought that this coal was formed approximately 299-359 million years ago.

The next type of coal, Bituminous coal, is the most abundant coal that contains 45-86 percent of carbon. "It is 100-300 million years old. It is found in West Virginia, Kentucky, and Pennsylvania" (Prud'Homme 11).

Sub-bituminous coal is the next most abundant type of coal with 35-45 percent carbon and found in Wyoming. It is over 100 million years old.

Lignite, "is the youngest and softest coal, and tends to be high in moisture. It contains only 25-35 percent carbon, but is high in hydrogen and oxygen. It is mainly used by power plants and is found in Texas and North Dakota" (Prud'Homme pg. 11).

Coal has been a source of energy around the globe for centuries in the time of human development. It is harvested by multiple different methods. "Including drilling of vertical and horizontal shafts: strip-mining, in which enormous shovels excavate surface layers of rock and earth to reveal coal seams; and mountaintop coal mining, in which entire mountaintops are removed, exposing coal deposits, while waste rock is dumped into valleys and streams" (Prud'Homme pg. 11). It is a reliable fuel source that has created an economy and jobs for millions of people globally. When it is burned, "energy from the Sun that was stored by plants many millions of years ago is being used, hence the actual burning of 'fossils'" (Lutgens & Tarbuck pg. 207). However, when coal is burned it produces carbon dioxide and releases soot into the atmosphere, increasing the impact of the Greenhouse Gas Effect. Also, "this air pollution is environmentally destructive , and, according to the National Research Council, kills more than 10,000 Americans every year" (Prud'Homme pg. 12). The air pollution created by burning coal clearly adversely affects the environment and human health. Emissions from coal burning include sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and particulate matter. Sulfur dioxide causes respiratory illness and is known to contribute to acid rain. Nitrogen oxides create smog and also cause respiratory illness. Carbon dioxide, as mentioned previously, is one of the primary greenhouse gases that contributes to the heating of the globe. The particulate matter created also contributes to smog and haze and is known to cause lung disease as well as respiratory illness. Besides the health risks from emissions, coals recovery in general creates problems. “Surface mining can turn the countryside into a scarred wasteland if careful (and costly) reclamation is not carried out to restore the land. Today all U.S. surface mines are required to reclaim the land. Although underground mining does not scar the landscape to the same degree, it has been costly in terms of human life and health. Strong federal safety regulations have made U.S. mining quite safe. However, collapsing roofs, gas explosions, and the required heavy equipment remain hazards” (Lutgens & Tarbuck pg. 208). Even so, coal remains one of the most popular sources of energy. “In the last decade, the world’s electricity production has doubled, and two-thirds of that increase has been powered by coal. Indeed, if this growth rate continues, coal could supplant oil as the world’s primary energy source” (Prud’Homme pg. 12). Some places, like China, rely heavily on coal as a source of energy.

The next fossil fuel we will discuss is Oil and Gas. I will group them together in this section as they are directly related. Oil is produced in the Earth by a very similar method to the described above detailing how fossil fuels in general are created. It is though that most of the oil buried on the Earth was created around 300 million years ago. The creation happened when, “diatoms died and decomposed on the seafloor. Diatoms are tiny sea creatures that convert sunlight directly into energy. After falling to the bottom of the ocean, they were buried under sediment and rock; the rock compressed the diatoms, trapping energy in their pinhead-sized bodies. Subjected to great heat and pressure, the carbon eventually turned into liquid hydrocarbons (an organic chemical compound of hydrogen and carbon) that is called 'crude oil'" (Prud'Homme pg. 13). This crude oil is harvest and oil refineries break down the hydrocarbons present in the liquid and create various products known as refined products. Refined products include, diesel fuel, aviation fuel, heating oil, kerosene, asphalt, lubricants, propane, naphtha, fertilizers and plastics. Most importantly, crude oil can be made into petroleum. An interesting concept about the conversion from crude oil to petroleum is that the result produces more as the crude oil expands when it is refined. "A 42-gallon barrel of crude oil generally produces 45 gallons of petroleum products" and " the vast majority-about 70 percent-of US petroleum consumption is used for transportation"(Prud'Homme pg. 15). This is because the gasoline fuels most Americans, and people around the world, are familiar with is a product of the refined petroleum product. Gas is one of the most important fuels used in engines that run from combustion power. So, not only cars, but most machines are dependent on the product.

Natural gas is another type of fossil fuel. It is a hydrocarbon called methane, which has a chemical structure composed of one central carbon atom with four hydrogen atoms attached. "Natural gas is lighter than air, has no natural odor (we mix it with mercaptan, a chemical with a strong sulfur odor, as a warning of leakage), is often found near petroleum deposits deep underground, and is highly flammable" (Prud'Homme pg. 15). Seismic surveying is used today to identify natural gas deposits which are formed from ancient organic matter similar to coal and oil. Conventional natural gas sites use a single vertical well to tap into free-flowing natural gas reservoirs. When collected natural gas requires very little processing. The unprocessed natural gas is referred to as wet, because it contains liquid hydrocarbons and nonhydrocarbon gases.

These are removed when processed to make consumer grade natural gas which is called dry. "Today, natural gas is used for generating electricity (36 percent) and for industrial (28 percent), residential (16 percent), and commercial use (11 percent). The remaining 9 percent is used by the energy industry operations, pipelines, and vehicle fuel. Gas is important for manufacturing steel, glass, paper, clothing, and many other goods, and provides raw material for plastics, paints, fertilizer, dyes, medicines, and explosives. It can be converted into ethane, a colorless and odorless gas that is important to the chemical industry. Natural gas provides heat for over half of America's homes and commercial establishments, and it powers stoves, water heaters, clothes driers, and other appliances" (Prud'Homme 17).

The use of natural gas has become increasingly popular due to disasters caused by alternative fossil fuel energy sources, which is directly related to the increase in hydraulic fracturing. Power plants that run on the burning of coal are considered to be outdated now as they produce the emissions described previously, harming the atmosphere. It is possible to remove these harmful emissions but it is expensive, making it an unappealing process for companies to implement. Oil-exploration in the deep sea has been slowed after the BP oil well in the Gulf of Mexico ruptured, causing the largest oil spill in American history. Nuclear power's safety was questioned after an earthquake and tsunami occurred near a Japanese nuclear plant in 2011. Nuclear power was also set back considering natural gas plants required much less maintenance and overall cost. Early in the use and mining of natural gas, concerns about the cost and limited supply of the gas threatened to keep the use of natural gas relatively low when compared to other energy sources. That was until the development and use of hydraulic fracturing, "which has significantly increased known gas reserves and lowered prices" (Prud'Homme pg. 17). Hydraulic fracturing increased the supply of the gas because its technologies could harvest the gases out of places once thought to be unobtainable. This new increased supply lowered the price of the natural gas, as it now was an abundant commodity. “A number of other factors-including ready capital, a trained workforce, greater access to pipelines by third parties, the ability to hedge the risks of gas exploration, and a robust energy market-helped to accelerate gas’s acceptance. Utilities saw it as stable, affordable, relatively clean source of power” (Prud’Homme pg. 18). The energy companies and the public, with the help of hydraulic fracturing, were beginning to accept natural gas as an energy source. “The EIA forecasts that domestic natural gas production will grow 44 percent –from 23 trillion cubic feet (tcf) to 31.1 tcf- between 2011 and 2040”. (Prud’Homme pg. 18).

The final fuels that need to be understood for this topic are unconventional gases and unconventional oils. Unconventional gases are shale gas, coal bed methane, and subterranean coal gasification, also known as tight gas. Unconventional oil is any oil acquired by drilling techniques that do not involve a traditional ground borehole. These unconventional fossil fuels are acquired through innovative technologies like hydraulic fracturing.

By understanding these fossil fuels, the reader can now understand the relationships of humans and fossil fuels, and why technology like hydraulic fracturing has been created. Our dependency on these fuels requires that every so often throughout history, a new technique for obtaining fuels must be created. Or a new source of energy must be discovered. Our modernized lives depend on the use of energy, whether that source is good for the environment or not is usually set on the back burner, so to speak. Now that we understand this idea, and what fossil fuels are, we can approach the topic of hydraulic fracturing with much more comprehension.

The central idea of hydraulic fracturing is a simple concept. It is designed to make or maintain fractures in oil or gas containing rock, with the intent to extract the gas or oil from a well bore. A well bore is essentially a vertical shaft dug into the ground. The concept of hydraulic fracturing to obtain hydrocarbons is by no means a modern one. It has existed since the beginning of the oil industry, although today, it has been heavily improved upon by engineering technological advancement. “In 1866, US patent No. 59,936 was issued to Civil War veteran Col. Edward Roberts, who developed and invention he titled simply, ‘Exploding Torpedo’. Roberts would lower an iron cylinder filled with 15 to 20 pounds of gunpowder into a drilled borehole until it reached oil-bearing strata. The torpedo was then exploded by means of a cap on top of the shell connected by wire to a detonator at the surface. Roberts also envisioned filling the well bore with water to provide ‘fluid tamping’ to concentrate the concussion and more efficiently fracture the rock” (Heinberg pg. 38). Roberts “exploding torpedo” was a success and can be said to be the start of the hydraulic fracturing era. Thousands of the torpedoes were used in Pennsylvania oil wells and, “production from the wells increased as much as 1,200% within the first week after the procedure” (Heinberg pg. 38). The success of Roberts invention earned him royalties from the oil companies he had contracts with. However, although all oil companies recognized the benefit of this new technology, many understandably, did not want to have to pay to use the invention. Thus, the age of innovation in terms of hydraulic fracturing began. Multiple oil companies began developing and testing hydraulic fracturing devices of their own, avoiding paying royalties to Roberts. This not only increased the overall demand for hydraulic fracturing but improved the technology itself.

Floyd Farris of Stanolind Oil and Gas began studying the use of water as a fracturing agent in the 1940’s. By the 1970’s, “the use of hydrofracturing became widespread within the petroleum industry, often in efforts aimed at ‘enhanced oil recovery’ (EOR) in conventional oil and gas fields. However, oil-and-gas-bearing shale rocks remained mostly out of bounds for drillers" (Heinberg pg. 39). The hydraulic fracturing technology was being widely used commercially even in its early and limited stage of development.

George P. Mitchell of Mitchel Energy & Development realized that shale has naturally occurring cracks, some shale cracked more than others. He realised that if this fracturing technology could be used to break the existing cracks more larger amounts of gas would be released and ultimately collected. By 1991, "Mitchell pioneered the use of horizontal drilling for natural gas, guiding wells down a kilometer or so, then bending the well bore to extend another kilometer. This accomplished two things: it provided more contact between the well bore and oil-or-gas-bearing strata, and it allowed producers to drill horizontally beneath neighbourhoods, schools, and airports" (Heinberg pg. 39). This provided oil companies with a huge advantage. They could now use horizontal drilling to reach places that would not be able to be used with traditional vertical drilling. A company could install infrastructure away from an area, drill vertically, then drill horizontally to get underneath already existing structures. Mitchell later developed the use of slick water. This involves, "adding friction-reducing gels to water to increase fluid flow in fractured wells" (Heinberg pg. 39). Combining the use of horizontal drilling and slick water starts to make this process look very similar to the hydraulic fracturing we know today.

As time went on the focus of the industry was set on improving the slick water, or fracturing fluids. They began to create, "more complex mixtures of fracturing fluids including fine sand and a laundry list of chemicals, many of them toxic. Some of these materials (such as sand) act as 'proppants', which are injected after the rock is initially fracked in order to prop open the newly created rock fractures. Other ingredients perform a range of functions, from optimizing fluid flow, to scouring the insides of the well casing" (Heinburg pg. 39). The original use of only water in aiding this process was being highly innovated. During the course of this innovation, a mirror effect happens that is similar to the case with Roberts exploding torpedo. Companies did not want to share their fracturing fluid mixtures with other companies for free, and it was not in the best interest of companies to have to pay competitors royalties to use their mixtures. This leads to another huge technological advancement of hydraulic fracturing as multiple companies were now studying the effects of adding various chemicals to their own fracturing mixtures.

One more key technological advancement in 2007 has led to the modern hydraulic fracturing process we know today. The concept of multi-well pad or cluster drilling involves, “the drilling of up to 16 wells from one industrial platform. This enables operators to concentrate machines and material in one place so as to reduce costs and accelerate well approvals” (Heinberg 40). With the combination of horizontal drilling techniques, enhanced fracturing fluids, and cluster drilling, hydraulic fracturing was quickly becoming a major competitor in terms of fossil fuel extractions. This technology was literally opening up new areas of rock that were not obtainable previously.

Now that we have covered what fossil fuels are and a bit of the history of hydraulic fracturing in the United States, we have to decide whether or not the use of this technology should continue in the United State. Hydraulic fracturing is highly controversial and has been the topic of debate between, oil and gas companies, the workforce of the companies, environmentalists, climate scientists, and the public in general. To explain why hydraulic fracturing is highly controversial we will start with the benefits.

Hydraulic fracturing, in this writing so far, seems to be like any other technology. It starts with a simplistic idea with the potential for many different uses and eventually is improved upon.

These ideas only continue to be improved upon if someone is benefiting from the use of them. So, who is benefiting from the use of hydraulic fracturing? The answer should be obvious, the oil and gas industries and the public will also eventually benefit as higher supply will create lower prices for the consumer. However, it is not so simplistic to track down who really is reaping the benefits of this technology. Early innovators like George Mitchell have definitely made a huge profit off of the technologies they have created early on in the development of this technology. Quick investors, buying land where hydraulic fracturing have also gained huge profits. “So, for a lucky few, hydraulic fracturing has been a highly lucrative gamble. Not everyone profits and the business remains volatile, yet the tales of quick riches are one of the things that keep others so feverishly interested” (Prud’Homme pg. 54). Lastly, consider the labor force of the oil and gas industry. The demand for hydraulic fracturing has surely lined some of their pockets or provided more opportunity to work.

One of the main benefits of hydraulic fracturing is the jobs it creates, so here we will expand on the topic of the work force involved with this process. As of 2010 hydraulic fracturing supported 600,000 jobs in the United States. Ed Morse, a Citigroup energy analyst claimed that by, “2020 the natural gas industry will have created some three million new jobs. Hydrofracking, he says, will add up to 3 percent to America’s gross domestic product and trillions of dollars of tax revenue” (Heinberg pg. 55). This industry will boost the economy and raise the number of employed people in the United States. More recently in 2012, President Obama claimed that, “ hydrofracking will supply a century’s worth of gas reserves and 600,000 new jobs by 2030” (prud’Homme pg. 55). Pennsylvania and West Virginia are two states we can examine to find examples of these claims. “In 2009 hydrofracking there created over 44,000 new jobs in Pennsylvania, $389 million in state and local tax revenue, and nearly $4 billion in value added to the state's economy" (Prud'Homme pg. 55). Similarly in the same year due to fracking West Virginia, "added 13,000 new jobs and over $220 million in federal, state and local tax revenue, and nearly $1 billion in value added to the state economy" (Prud'Homme pg. 55). It is clear that the introduction of hydraulic fracturing benefits not only the company owners but also the direct communities involved and the nation as a whole.

Another important benefit of hydraulic fracturing is the increase in natural gas resources we are able to obtain. When there is a large amount of a commodity, the consumers usually benefit. This is what we are seeing from the introduction of hydraulic fracturing in the United States. The increase in natural gas reserves has indeed lowered the prices of the gas for Americans. "Largely thanks to hydrofracking, annual production has climbed to some 30 trillion cubic feet a year, and prices have dropped precipitously, from about $13 per million BTUs in 2006 to less than $4 per million BTUs in 2013" (Prud'Homme pg. 56). The lowering of the natural gas prices eases the burden to American families financially. The ANGA, or America's Natural Gas Association, explains that "between 2012 and 2015 low gas prices will add $926 in disposable income to each household, a number that could reach $2000 by 2035" (Prud'Homme pg. 56). Lower gas prices will enable American families to be able to spend their incomes on different items, resulting in a boost to different local economies. Aside from just American families, companies also benefit from the lower gas prices due to abundance. "According to a study done by scientists at MIT, residential and commercial buildings account for 40 percent of America's total energy consumption, in the form of electricity or gas, making up over half the country's demand for gas. Lower gas prices have meant that the cost of heating schools and other government buildings, often itemized on local tax bills, is falling" (Prud'Homme pg. 60).

Basically, an increase in natural gas reserves means a decrease to the price of many American commodities.

In an increase in the supply of natural gas from fracking could also have more direct impacts. Transportation in the United States consumes a large part of its gas use, and the use of gas contributes immensely to greenhouse gas emissions. “The place where natural gas increases could ultimately have the biggest impact is by replacing gasoline in the world’s cars, trucks, and buses. At the moment, transportation accounts for 70 percent of America’s petroleum use, and 30 percent of US carbon emissions” (Prud’Homme pg. 62). Replacing gasoline with natural gas could be a temporary solution to the United States carbon emissions problem. Ultimately, we need to move completely away from fossil fuels, but natural gases could be the intermediate step that weens Americans off their fossil fuel dependency. “In 2011, President Obama vowed to cut oil consumption by a third in the next decade, and two years later he said that emissions would be cut by 17 percent by 2020. Natural gas is an important part of his plan to reduce oil imports and greenhouse gases” (Prud’Homme pg. 62). This is also a critical benefit from hydraulic fracturing. Reducing the need to import oil from foreign sources greatly reduces debt and helps the economy to be self-sustained. The reduction of emissions comes from the fact that, “the combustion of natural gas produces 30 percent less carbon dioxide than oil, and could be used- either directly, as compressed natural gas (CNG) or liquid natural gas (LNG), or indirectly, by converting natural gas into liquid fuel power”(Prod’Homme pg. 62).

These are compelling reasons to support the use of natural gas recovered from hydraulic fracturing. It would lower prices for Americans, would cut greenhouse gas emissions, lower the dependency on gasoline, create jobs, and boost the economy. However, before promoting the use of hydraulic fracturing it is important to understand the negative aspects involved with allowing the process to be used in America.

There are a few topics needed to be discussed before deciding whether or not to support the use of hydraulic fracturing. First questions about the process itself must be considered. Will the construction of and daily operation of the hydraulic fracturing site be safe? Does injecting fracturing fluids into the ground effect the groundwater and soil? Will the fluid eventually resurface? Will the recovery, processing, and transportation of the products pose a risk to the areas? What is done with the waste generated by the product, and what kind of state is the area once used left in? Lastly, what are the social impacts on the people surrounding the areas where hydraulic fracturing is being done? These all raise potential issues correlated with hydraulic fracturing. This brief writing will cover some of the most critical areas on the planet, the water, air, and climate.

Water is an extremely important commodity and critical to all life on Earth. So, the effects hydraulic fracturing has on the water supply is important to understand. Even though fracturing fluids are proprietary, it is known that the majority of all of these fracturing fluids are composed of water as the base of the solvent. Two main concerns, relating to water, arise from this fact. The quantity of water used, and the quality of the water after it is used. Hydraulic fracturing uses an immense amount of water, "about 5 million gallons per well, on average-that it can deplete groundwater supplies faster than nature can recharge them, especially in dry regions like Texas or California" (Prud'Homme pg. 71). Water use and groundwater depletion is a huge factor when weighing the pros and cons of hydraulic fracturing. The second main concern is the direct injection of toxic chemicals, that fracturing fluids are composed of, directly into the ground at extremely high pressures. There is a huge potential for groundwater contamination during this process. direct injection is only the start of the potential contamination. The water used in fracturing operations is eventually pumped back to the surface. “At that point, the water carries with it not only a secret cocktail of chemicals added so that it can accomplish its mission, but also highly corrosive salts, carcinogenic benzene, and radioactive elements like cesium and uranium, all leached from rock strata miles underground” (Heinberg pg. 81).

This leaves the company with toxic wastewater; how do they deal with this? There are several different methods, all of which create their own problems. One option is to directly inject the wastewater into abandoned wells or newly drilled holes for containing wastewater. This method is problematic because it involves, “taking precious freshwater out of aquifers or rivers, polluting it, and then burying it so that it can never be used again” (Heinberg pg. 82). Another option is to hold the wastewater in evaporation pools or send the water to be treated by local municipalities. Evaporation pools are not efficient, often leaking. They are also known to poison birds and local wildlife. So, this option does not come free from problems. Lastly sending wastewater to municipalities creates a plethora of problems. “Municipal water treatment plants are poorly equipped to remove the pollutants of in fracking wastewater, especially when many of those pollutants are company secrets. An additional problem for wastewater treatment plants is the radioactivity released in fracking: reports from the US environmental Protection Agency (EPA) made public in 2011 showed that fracking wastewater is too radioactive to be dealt with safely by municipal treatment plants, raising the specter of entire cities drinking radioactive water so that residents can continue burning natural gas” (Heinberg pg. 83). The treatment of fracturing wastewater is highly problematic even when the entire process of drilling is done correctly. When accidents happen during drilling, fracturing fluids leak out from the site and pollute surrounding bodies of water, harming wildlife and human health.

Moving on from the topic of water, we will discuss another critical part of the Earth, essential to all living things present. The air. How does hydraulic fracturing affect the air all life depends on. Natural gas is mainly composed of methane. It is a is a colorless, odorless and nontoxic gas in low concentrations. Although, when methane is released into the atmosphere, through drilling or other sources, it reacts to form carbon dioxide and water vapors. This will be critical to understand when covering the climate section of the negatives of hydraulic fracturing later in this paper. For now, we will focus on the effects of the other chemicals present in natural gas. These include hydrogen sulfide, ethane, propane, butane, pentane, benzene, and other hydrocarbons. All of which degrade air quality. Besides the natural gas itself there are, "emissions from trucks, compressors, pumps, and other equipment used in drilling containing a complex mixture of benzene, toulene and xylene, as well as other volatile organic compound" (Heinberg pg. 85). The increase in activity in the area by trucks and other mining equipment in the area create high levels of dust, which are a known pollutant to air. On site, "some chemicals associated with drilling combine with nitrogen oxides to form ground-level ozone" (Heinberg pg. 85). Ozone is usually associated with exhaust from cars, but hydraulic fracturing sites are also responsible for creating it. Ozone not only impacts the climate but also humans directly, "ozone inflames lung tissues and can cause coughing, chest pains, and asthma. Human health is harmed by both prolonged exposure to low-level ozone concentrations and by exposure to higher levels for shorter durations" (Heinberg pg. 86).

Unfortunately, this is not the end of the problems associated with air quality that hydraulic fracturing creates. A study by The Endocrine Disruption Exchange measured over 44 known hazardous chemical pollutants at hydraulic fracturing sites in Colorado. "The study detected pollutants up to seven-tenths of a mile from the well site. Many of the chemicals detected are known to impact the brain and nervous system; some are known hormonal system disruptors. The human endocrine system is so sensitive that even tiny doses of some of these chemicals, measured in parts per billion, can lead to large health effects" (Heinberg pg. 87). Keep in mind that with the expansion of hydraulic fracturing sites, facilities are moving closer to populated areas. Facilities in some states are currently only hundreds of feet away from schools and homes. Clearly, hydraulic fracturing damages air quality, but the companies will not admit this and do not plan to shield the public or their own workers from the pollution.

Lastly, let's consider the climate before making our final decision on whether or not to support hydraulic fracturing. Since natural gas plants produce less than half of the carbon dioxide emissions than coal plants, based only on combustion, it can be argued that natural gas plants are actually better for the environment. That they are reducing overall carbon dioxide emissions and should be kept in use while the country figures out a plan to switch to alternative energy sources. However, recent studies show that this may be a false statement lead by misleading numbers. "In, 2011 Robert Howarth, professor of ecology at Cornell University, led a study published in *Climatic Change* concluding that as much as 1.9% of the gas in the typical well escapes to the atmosphere during fracking, compared with 0.01%in a conventional gas well. This turns out to make an enormous difference: over short time frames, methane is 20 to 100 times as powerful a greenhouse gas as carbon dioxide. If Howarth's figures are accurate, this means that life-cycle greenhouse gas (CHG) emissions from shale gas are 20% to 100% higher than coal on a 20-year time frame basis" (Heinberg pg. 90). This information, if accurate, shows that in reality natural gas is actually worse for the environment than coal. The step away from coal to natural gas is actually making the climate worse. It was thought natural gas could a substitute for coal while we find new sources of energy, but this is not the answer.

Now that the benefits and negatives of hydraulic fracturing have been addressed an informed decision can be made on whether or not to support the process. In my honest opinion, the negatives severely outweigh the benefits of hydraulic fracturing. I understand the importance of the economy and providing people with jobs and affordable products. However, I would not trade these things in for the price of destroying the environment. The problems created by hydraulic fracturing are long term and will impact of all humanity. The jobs and affordable products created by hydraulic fracturing are meaningless, as hydraulic fracturing destroys the Earth ultimately leaving us in a dire situation where those jobs and products are non-existent. Instead of focusing on new ways to harvest fossil fuels, furthering our dependency on them, this type of research and development should be focused on alternative energies. The time spent arguing over controversial subjects on fossil fuels should be spent on coming up with a realistic plan that enables us to move away from these fuels. Clearly, we cannot remain dependent on fossil fuels forever. There is a limited supply and before we can even utilize the remaining supply, we will irreversibly damage the planet.

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