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The Economic and Environmental Justice Implications of Hydraulic Fracturing in 21st Century North America

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Introduction:

The term "energy crisis" has been a circulating topic in societal discourse recently as the political, economic, and environmental future of the United States is considered. As a result of the Industrial Revolution, the country's dependency on energy has been increasing exponentially as we rely on it as a means for societal and international advancement. For decades America has primarily used coal and oil to run our country – individuals, businesses, homes, companies, industrial sites, stores, restaurants, etc. etc. cannot function without them. Lights, laptops, toasters, heaters, cars, movies, everything from menial everyday tasks to multi-national investments utilize and rely on the presence and availability of gas and oil. But the availability is exactly what is in question, and the term crisis does not exaggerate the state America could reach. Multiple issues have arisen from this dependency in regards to public health, economic viability, and negative environmental impacts of the industries, and most visibly, the foreign relations problems in terms of safety and power. Because of these tangible threats, policy and industry incentives are focused on finding alternative, domestic, and "clean(ish)" sources of energy to help the U.S. stabilize economically. By keeping money circulating internally, creating jobs instead of outsourcing, increasing research, and creating a strong national identity, this push should be beneficial to all aspects of American life – finding new sources of energy does more than stabilize the economy. This stability provides a positive social temperament, institutes a driven, higher functioning society, and supports a healthy future for America, and the planet.

Natural gas is one of these alternative sources. Although natural gas has been used in the United States as an energy source since the 1800's, it has never been a primary source. Currently, natural gas accounts for about 25% of the U.S. energy demand and heats about 51%

of U.S. households. [1] New technologies have made previously unavailable natural gas reserves accessible for industrial and home use, increasing the opportunity for use of natural gas as a more dominate source of energy. But with these new technologies come new problems. Extracting natural gas from shale rock is done primarily through the process of hydraulic fracturing (fracking). Natural gas drilling is a complex topic, laced with myths ranging from it being an environmentally clean burning fuel, to being the cause of earthquakes. While there is some truth to these beliefs, the intricacies make it a much more multifaceted issue. While hydrofracking is vital to the extraction of natural gas – which is in turn vital to the country's energy demand and an assumed necessary component in the shift off of coal and foreign oil – it is a delicate topic and needs to be highly monitored and regulated in order for it to be a helpful asset instead of harmful for the economy and the environment. Although getting America off oil and coal is essential for the success of the environmental and economic future, focusing all our energy and resources on the development and improvement of the natural gas industry has the potential to be just as environmentally harmful and is distressing America's internal structure. Hydrofracking and natural gas extraction should therefore be avoided and the consumer mindset driving such expansions must be changed if the country hopes to thrive long-term via sustainable progress in the world market.

Studying the history, the economic/political implications, and the ethical effects of hydraulic fracturing, the following will assess the viability of the process in regards to environmental and socio-economic sustainability. By focusing on the industry's physical movement from the West and South to the East, primarily comparing historic drilling and the sequential effects in the San Juan Basin to the projected impacts of drilling in Marcellus Shale,

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[1] API oil and gas overview

and analyzing the ethical significance of Environmental Justice in the specific locations of natural gas wells the problems become evident. Does the economic assessment of hydrofracking really regard all externalities when evaluating the cost of hydrofracking – the physical land for example? The water? People's lives that are impacted? Or has society been so blinded by capitalism that they can no longer see that life is just as important as "advancement" and production?

Chapter 1: What is Hydraulic Fracturing and What are the Problems Associated with it?

Hydraulic Fracturing (hydrofracking or simply fracking) is the injection of a mixture of water, sand, and chemicals at high pressures deep in the earth in order to extract natural gas that is imbedded in the rock shale layers.[2] The mixture is made up of about 95% water, 4.5% sand, and .5 to 2% chemicals. [3] Recently, hydrofracking has been combined with horizontal drilling, which is why the industry has been growing so rapidly. Horizontal drilling allows for a well to tap into a much larger amout of natural gas, spreading the area just one well can cover, thus preventing the creation of more well heads and hole and lowering the (visible, above ground) environmental impact. The well is drilled just below the water (of an aquifer or any underground source of drinking water USDW) when surface casing is inserted to make sure the fresh water is isolated from the hole. Cement is then forced between the casing and the hole, completely separating the two. This step is essential for the prevention of ground water contamination, and

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[2] American Petroleum Institute. "Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing." June 2009.
[3] American Petroleum Institute. "Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing." June 2009.

if it is neglected or done improperly – which it often is – the flow of the fracking fluids is easily mixed with drinking water sources. But more on this later. Up to this point, drilling proceeds just like any other vertical well. The hole is then drilled further and further down to the shale containing the natural gas, hundreds to thousands of feet below ground, this is where "the kick-off point," where the horizontal drilling actually begins, about one fourth a mile down. [4] Once drilling is complete, more casing is inserted, and the anulis – the space between the casing and the wall of the hole – is filled with cement. A gun is then lowered into the hole and an electrical current is sent down the hole. The charge that is set off shoots small holes through the casing and the cement into the actual shale. Then, the fracking mixture is pushed down the hole at high pressures, forcing it through the perforations and into the shale. The high pressures become too strong for the rock and it fractures. A fairway is created that connects the gas reservoir to the well, allowing the gas to flow freely up the well-bore and out. Plugs are put in place at the end of each section, so the processes can be repeated, thus "multi-stage fracturing" occurs. Because of this phasing, horizontal sections of the well can reach thousands of feet away from the wellhead. Similarly, due to the high pressures, the fractures that are created reach hundreds of feet away from the initial perforation, allowing for large volumes of gas to be collected.[5] Because the shale is so tight the gas does not flow naturally, so with out the high pressures and large amounts of water it would be extremely inefficient to try and obtain the gas.

But the water is not efficient alone. The sand that is mixed in acts as a proppant to keep the fractures "propped" open after the initial injection has been stopped. Some chemicals that are a part of the mixture also work as proppants but they are added for a variety of reasons:

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[4] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.
[5] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.

formation clean up, preventing bacteria growth, foam stabilization, leak-off inhibition, surface tension reduction, friction reducers, oxidizing breakers, etc. [6] Below is a graph from the oil and gas company Encana listing various chemicals and their uses in the Encana fracking process[7]:

% of Total	Product category	Main ingredient	Purpose
~99.5%	Water	H_20	Creates fractures and delivers the sand to the zone of interest
	Sand (proppant)	Silica	Props fractures open to allow gas to flow
~0.50%	Gel	Guar gum	Thickens water to suspend the sand
	Friction reducer	Polyacrylamide	Minimize friction between the fluid and the pipe
	Crosslinker	Borate salts or Zirconium	Greatly increases base gel viscosity
	Anti-bacterial agents	Glutaraldehyde	Eliminates any bacteria in the

[6] United States Environmental Protection Agency. "Hydraulic Fracturing Background Information." Washington DC, march 2012
[7] www.encana.com

		water that may produce corrosive byproducts.
Breaker	Ammonium or Sodium persulfate	Breaks gel to lower viscosity
Corrosion inhibitor	n, n-dimethyl formamide	Prevents corrosion of the pipe
Iron control	Citric acid	Prevents metal oxides precipitation
Clay stabilizer	Potassium or Quaternary chloride	Creates a brine carrier fluid
pH adjusting agent	Sodium hydroxide or Potassium carbonate	Maintains desired pH for crosslinker effectiveness
Surfactant	Isopropanol	Used for water recovery and preventing emulsions

Many of the chemicals used can be found in household items like soaps, make up and even food. Regardless, many of them are toxic to humans upon contact or when consumed. The list above does not account for all the chemicals used by all companies; there is no complete list and many chemicals used will remain a mystery for the public because there is no federal law requiring that companies disclose this information. All of the 27 states where hydraulic fracturing occurs apparently do require this disclosure though.

The final step in the fracking processes is the actual transportation of the gas to its point of use. There is an intricate piping system through out the country, requiring acres and acres of land, some passing through private property.

Although natural gas does not emit carbon dioxide (CO2) when it is burned, people therefore mistakenly consider it a “clean fuel,” but the processes of extraction is hardly “clean” not to mention the chemical make up of natural gas makes it one of the largest contributions to the greenhouse effect. The amount of water used for extraction and then the storing or disposing of that water, the health concerns around the toxic chemicals used via surface and ground water contamination, the air pollution, and land destruction all pose various problems. The question is, do the pros out-weigh the cons when it comes to using natural gas a primary energy source for America? The public associate climate change and greenhouse gases almost exclusively with carbon dioxide; while CO2 is the number one offender when in comes climate change, and humans are most connection to CO2 emissions as opposed to other greenhouse gases, what people forget (or are manipulated into naïveté about) is that there are multiple gases that contribute to climate change. And human’s contribute to these emissions as well: “Methane (CH4) is second only to carbon dioxide (CO2) in it’s contribution to the greenhouse effect.” [8] “The following graph illustrates the rise in atmospheric methane from 1008 to 2001. Note that the increase in methane's concentration in the atmosphere is exponential in nature. An extrapolation into the immediate future would suggest continued annual increases:[9]

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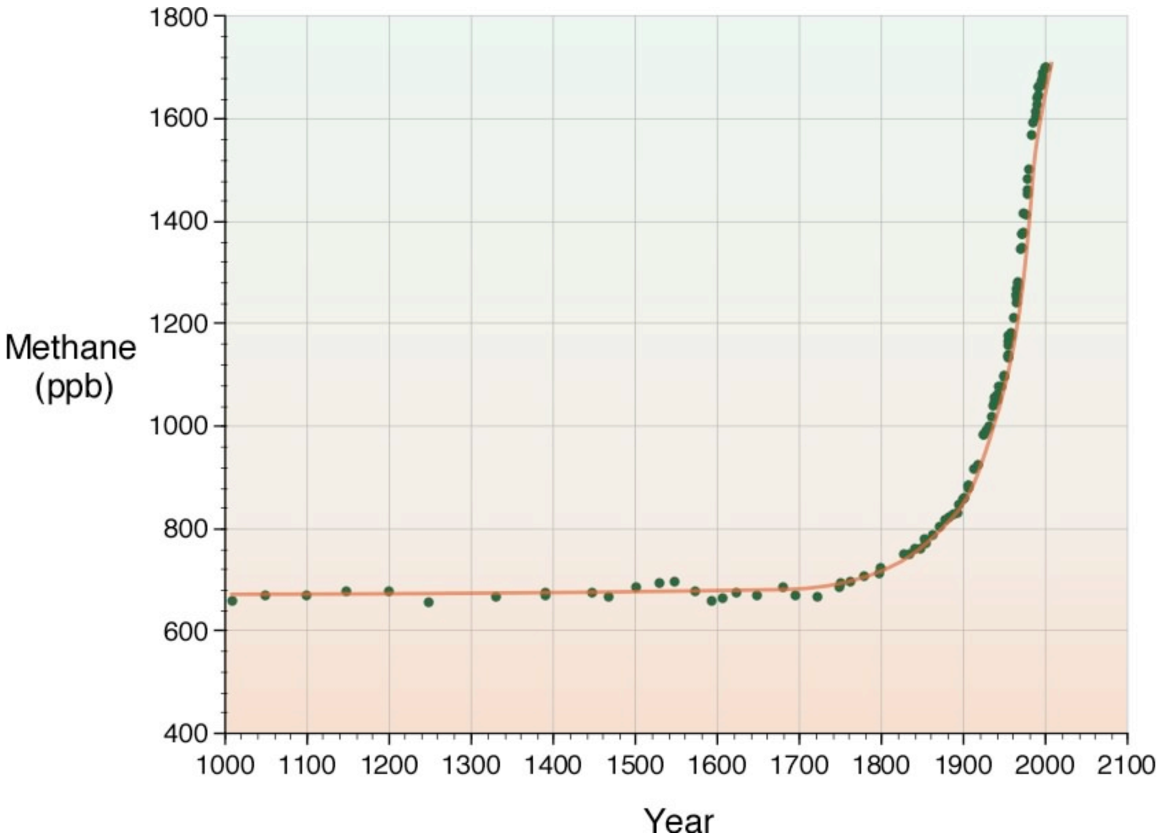
[8] Dave Reay; C Michael Hogan; Peter Hughes. "Methane". Encyclopedia of Earth. April 20, 2010.
[9] Dave Reay, C Michael Hogan. NOAA (Content source);Howard Hanson, Michael Pidwirny. "Greenhouse gas". Encyclopedia of Earth. July 5, 2011.



Methane is the primary component in natural gas. Methane is only released when natural gas is unburned, but large losses occur during extraction, processing, storage, transmission, and distribution.[10] Methane is released naturally from wetlands, termites, vegetation, livestock, and many other naturally occurring sources, resulting in the release about 250 million tonnes[11] annually, while "Methane emissions resulting from human activities are now thought to exceed those from natural sources, annual emissions being around 320 million tonnes."[12] Obviously not all of these emissions come from hydrofracking, or other natural gas extraction method – much is attributed to coal and oil extraction – but the natural gas industry makes up for a lot of that. And, these numbers will inevitably increase with the increase in overall natural gas extraction,

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[10] Nehring, Richard. Personal interview. 14 January 2012.
[11] Milton Beychok; C Michael Hogan. "Natural gas". Encyclopedia of Earth. Sept 20, 2011
[12] Dave Reay; C Michael Hogan; Peter Hughes. "Methane". Encyclopedia of Earth. April 20, 2010.

especially with the drastic increase of hydrofracking. The reason that methane is not considered as bad as carbon dioxide is that it is released in much smaller amounts/percentages, but overall, CH_4 has radiactive forcing 30 times that of CO_2, if not more: "This means that every kilogram of methane emitted to the atmosphere has the equivalent forcing effect on the Earth's climate of 30 times that of carbon dioxide over a 100 year period; however, recent research by Shindell et al. has demonstrated that the actual strength of methane is much higher than conventionally thought.[13]" So although emissions of CO_2 during the burning of natural gas are insignificant, greenhouse gas emission occurs during the process of hydrofracking from extraction to distribution, and the contributions to climate change must be considered when considering natural gas as an alternative to coal and oil.

Chapter 2: The History of Hydraulic Fracturing

Natural gas has been caught in rocks for thousands of years, since microscopic plants and animals absorbed carbon from the sun, died, decomposed and sediment formed that got buried over and over again. As heat and pressure began to rise, the amount of pressure and the degree of heat would determine whether the material would become oil or natural gas. And once natural gas formed, it travelled up through the rocks surrounding it, until it found impermeable layers of rocks or clay where it was trapped. Until Americans discovered they could use it to heat their houses or fuel their cars. Hydraulic Fracturing was first used in the U.S. in 1947 into limestone in Kansas. At that time, the operation was not far enough developed for it to become commercially successful. In the 1970's, with support from the federal government, research on

[13] Dave Reay; C Michael Hogan; Peter Hughes. "Methane". Encyclopedia of Earth. April 20, 2010.

geographic mapping and drilling techniques allowed the industry to better solidify the process.[14] And ever since, fracking has been a common used method. As noted before, though, until recently there have been a lot of natural gas plays that were not economically efficient to drill because the amount of money and time did not equate to the return of natural gas – primarily because without horizontal drilling a much smaller percentage of gas could have been reached from one head. Now one drill head can return the same amount of gas that four or five vertical drills would have done before.

Since 2009, the natural gas reserves have grown 30% and on-shore gas production has increased by more that 20%. [15] Natural gas can be found in multiple types of rock formation, shale and coalbed methane reservoirs or "plays" are where hydraulic fracturing is most useful. There are rock shale and reservoirs all over the United States – the most developed places are in Texas, Louisiana, Wyoming, and Oklahoma. There are millions of wells primarily located in the mountainous west like Colorado, the South, and more recently the Northeast Appalachian region. [16] The San Juan basin under Colorado and New Mexico is the most productive coalbed methane basin in North America, producing 800 thousand cubic feet of gas per day and 800 billion cubic feet per year. In 2001, the San Juan basin had 2,550 wells in operation. The Fruitland Formation is the most developed and lays 550-4,000 feet deep under an underground source of drinking water[17]. The other most productive basins are the Black Warrior in Alabama and Mississippi, the Central Appalachian spanning across Kentucky, Tennessee, Virginia and West Virginia, and

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[14] American Petroleum Institute. "Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing." June 2009.
[15] American Petroleum Institute. "Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing." June 2009.
[16] American Petroleum Institute. "Measuring the Economic and Energy Impacts of Proposals to Regulate Hydraulic Fracturing." June 2009.
[17] United States Environmental Protection Agency. "Hydraulic Fracturing Background Information." Washington DC, march 2012.

the Powder River basin located in Wyoming and Montana. [18] The five most productive shale fields are the Barnet Shale in Texas providing 6 percent of US natural gas, the Haynesville Shale under Arkansas, Louisiana, and Texas, the Fayetteville Shale in Arkansas, the Woodford shale under Oklahoma, and the Marcellus Shale spread under Pennsylvania, West Virginia, Ohio, New York, and Maryland.

Chapter 3: Public Health Concerns

Most of the areas that have been developed have very low populations where the people immediately affected – through their drinking water and land disturbance – are of lower-income and have low political power or influence. The most dominant problem has to do with all aspects of water. Land disturbance, air pollution, and fossil fuel burning for production and transportation are the other environmental and public health issues associated with hydrofracking. Moving from the past to the present, west and south to east, the issues seem to grow as the industry grows.

The west is dry. The people who live in the west, many farmers and ranchers, have been struggling with a solution to their water problems for thousands of years. Not only having to compete with the natural landscape and elements, but other farmers or ranchers whose cattle and crops need the water too. And, they have been competing with the oil and gas companies for the rights to water as well. There have been many recorded cases of private property owners losing water from their underground wells as a result of a fracking well being drilled near their land. The first step in coalbed methane production from a newly drilled well is dewatering the well.

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[18] United States Environmental Protection Agency. "Hydraulic Fracturing Background Information." Washington DC, march 2012.

This dewatering could cause people's water wells coming from the same source to dry up. The EPA's study of hydrofracking and it's effects on drinking water acknowledged water wells drying up, especially in the Central Appalachian Basin, to be connected to hydrofracking. From the 1990s to 2000, Hundreds to thousands of wells dried up right after coalbed methane wells were installed near the property – the first step in coalbed methane production from a newly drilled well is to dewater the well, so the gas can flow into the well bore, and if people have drinking water wells into these same coals being developed, their wells may be dewater as a result[19]. Many oil and gas companies in the area provided compensation to some of the individuals through money, newly drilled wells, or temporary provisions of potable water [20]. But many explained the water lose as a result of droughts and other natural causes and ultimately, the Virginia Division of Oil and Gas claimed the coalbed methane production had nothing to do with it as well.

This new serge in the need for domestic energy and with it the increased demand for natural gas has caused a surge in the number of wells and the speed at which they are popping up. The farmers are having a hard time keeping up. As the Denver Post recently reported, the farmers having to bid for water against huge corporations, backed by investors with a lot of money, have little chance at getting the water they need for their crops. [21] As the article states, water used on farms not only grows crops but also provides for other eco-systems along the way. Plus, "contaminated" water that leaves farms is easily cleaned – removing manure for water is

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[19] Nehring, Richard. Personal interview. 14 January 2012.
United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.
[21] Finley, Bruce. "Fracking Bidders Top Farmers at Water Auction." *The Denver Post*. 2 April, 2012.

what wastewater plants were made for – and recycled for other uses. But the small percent of water that is salvaged from fracking sites cannot boast of the same quality.[22]

The water that is used for fracking is generally fresh, because the chemicals that are added work best with clean water and it would require adding high concentrations and more chemicals with "dirtier" water. Which means more money, and more toxins – neither of which is a good thing. Already this is a fairly large problem because the fresh water supply is limited, and at the end of the day, Americans can survive without their hummers, but cannot without water. Coalbed methane wells need 50,000-330,000 gallons of water per well and shale gas need 2-4 million gallons a well. Additionally, one well can be fracked up to 18 times per well, increasing the amount of water needed [23]. About 35,000 wells are fractured in a year in the US and so that is around 70-140 billion gallons of fresh water used a year…the same amount of water 40-80 cities with a population of 50,000 would use in just one year. [24] While the exact amount of water that is recovered from a well varies drastically based on the location, the type of rock, etc. overall, the number is low. Around 25-50% of the water that is shot into the ground through fracking is recovered. With percentages as low as 10 and as high as 75, this is still not a high recovery rate. None of the states where drilling is done require companies to report the volume of water recovered – "flow back"[25] so the exact amount is not know, even by the companies themselves. So. There is an unknown amount of chemical-laced water floating around in the porous rocks underground, near many USDW that is 100% unaccounted for, and untraceable. Not only is this a public health concern, but the chemicals negatively effect the environment they

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[22] Finley, Bruce. "Fracking Bidders Top Farmers at Water Auction." *The Denver Post*. 2 April, 2012.
[23] scnycgroup.org Gusti Bogok
[24] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.
[25] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.

exist in, disturbing naturally occurring cycles and changing the chemical make up of various natural minerals etc. And as mentioned above, this is a complete loss of fresh water. Golf courses use millions of gallons of water to water their grass, and while some of it is lost to evaporation, the reclaimed water is always reused and recycled. Once fracking water is used, it is very unlikely to be reused or recycled. But, let's address the water that *is* accounted for.

The fracking fluid that is sucked back out of the well contains all the chemicals that were added before. These toxins contain barium and other ions, have volatile organic compounds like benzene and toluene, can be carcinogenic, there is an unending list of physical and mental issues derived from the chemicals used to improve fracking. The water is also now called "brine" because of the high salt levels – saltier generally than ocean water – needless to say, it would be highly dangerous for the environment and public health for this water to enter any surface water or underground water resources. The flow back is generally stored in tanks or pits near the well site. The initial problem is the fear of surface spills or leaks, through accidents or equipment failures. This can effect the workers who come in contact with the water directly, and the spilled water can then leak into the groundwater, or enter with other surface water via roads and drains with the other – clean – surface water, thus spreading to the greater public. Publicly owned treatment works are not able to clean fracking wastewater: they are not designed to treat fluids that contain radionuclides or high concentrations of TDS[26]. So, the water either goes in undetected or breaks the plant costing millions of dollars in repairs. When the EPA drafted their plans and researched many companies they determined that: "it is unclear what practices are used on-site to prevent, contain, or mitigate accidental releases of flow back and produced water."[27] As far as the tanks go, 18 of 27 states require permits for the tanks or pits, 23 require a liner, and

[26]See above
[27] See above

16 limit the duration the tanks/pits can be in use.[28] What happens after the time-limit is up? Since there is literally nothing tracing this water…it could go anywhere. And once the well has been drained of all it's natural gas and the cite is abandoned…do the companies return regularly to check on the tanks? Because this is obviously cost and time efficient for them, to pay someone to use fuel to drive all the way out to the middle of no where Arkansas just to look at a little tank, I'm sure they do…not.

But if the water is treated, it is done through privately owned treatment facilities. The water can be "cleaned" through distillation, reverse osmosis and filtration, but, again, "much is unknown about the efficacy of current treatment processes for adequately removing certain flow back and produced water constituents" [29] and until this is further developed, using recycled fracking wastewater is extremely unsafe. Plus, to build and operate one of those facilities uses huge amounts of energy, burning fossil fuels, etc.. Again, establishing the myth that natural gas is "clean."

The most common form of disposal is through underground injection – the wastewater that is removed from the well is injected into the ground again for safe storage in wells thousands of feet below the surface. UIC is monitored under the Safe Drinking Act of 1974, and oil and gas production disposal wells, called class II wells, require permits and: "The owners or operators of the wells must meet all applicable requirements, including strict construction and conversion standards and regular testing and inspection."[30] The wells seem to have strict policies that would guarantee ground water safety from toxic hydrofracking fluid. Unfortunately, via the Energy Policy Act of 2005, which offers incentives for alternative energy

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[28] See above
[29] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.
[30] United States Environmental Protection Agency. "Class II Wells – Oil and Gas Related Injection Wells (Class II)." Washington DC, 2012.

use and exploration, hydraulic fracking flow back goes completely unnoticed. Well, this is not entirely true; if diesel fuel is used as an additive, then the waste falls under the UIC mentioned in the Act. Otherwise:

SEC. 322. HYDRAULIC FRACTURING.

Paragraph (1) of section 1421(d) of the Safe Drinking Water Act (42 U.S.C. 300h(d)) is amended to read as follows:

''(1) UNDERGROUND INJECTION.—The term 'underground injection'— ''(A) means the subsurface emplacement of fluids by well injection; and

''(B) excludes—

''(i) the underground injection of natural gas for purposes of storage; and ''(ii) the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities.''[31].

And so, the federal government requires no permit for the injection of toxic water into the ground near UDWS. And, it has also been debated whether diesel fuel additives are regulated at all – there are no recorded permits for "diesel-based fracking" after 2005 because the EPA failed in creating rules for attaining permits. [32] Many states though require permits for such wells and do have established rules and regulations that tend to be followed. But, requiring a permit can only do so much; to truly regulate these operations requires constant site visits by employees not associated with the company – and thus not lenient on rules – adapted for all the different companies, well-types, and locations. There are thousands of class II wells in operation

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[31] United States Environmental Protection Agency. "Class II Wells – Oil and Gas Related Injection Wells (Class II)." Washington DC, 2012.

[32] Zeller, Tom Jr. "Gas drilling Technique is Labeled Violation." *The New York Times,* January 2011.

everyday pumping billions of gallons of brine-y flow back into the earth all over the country[33]. It does not make economic sense, or logical sense, to employ thousands of people to regulate these wells, and is it just not possible for all wells to be checked regularly by currently employed state officials. One would assume though that oil and gas companies would self-regulate, doing extensive geological research and testing, setting up trackers, have regular check up, etc. And most do. But, careless underground injection has been recognized as the source of multiple environmental issues including earthquakes and water contamination all over the country since 1970. About 100 earthquakes are recorded as being associated with underground injection [34]. Oil and gas companies dispute these beliefs, claiming that the earthquakes occurred because of natural reasons having absolutely nothing to do with the large amounts of high-pressured water being continually forced against the faults in the ground…Most recently, there were multiple earthquakes in Youngstown, Ohio that caused an uproar in the politically charged issue of drilling in the Marcellus shale. Seismologists John Armbruster says disposal of toxic drilling waste was the cause of both quakes: "I compare it to a hydraulic jack. The pressure in the well is a thousand pounds per square inch. Put that over a piece of fault that's one kilometer by one kilometer and you have enough pressure to move a piece of Earth" [35] Since the earthquakes the D&L Energy drill has been shut down and the state intends to establish stricter regulations including "comprehensive geological data when requesting a drill site, pressure and volume monitoring, and an automatic shut-off when these get out of line."[36] First of all, these should already be required by the state…it causes wonder as to what, if anything, the permits actually do

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[33] United States Environmental Protection Agency. "Class II Wells – Oil and Gas Related Injection Wells (Class II)." Washington DC, 2012
[34] http://www.realscience.us/2011/10/25/fracking-earthquakes/
[35] Mufson, Steven. "Can the Shale gas boom save Ohio?" *The Washington Post:* 3, March, 2012.

[36] Mufson, Steven. "Can the Shale gas boom save Ohio?" *The Washington Post:* 3, March, 2012.

require. Secondly, the state "intends" to do this. Who knows when, or to what degree this will actually be implemented. Studying past regulations – the federal act regarding diesel fuel for example – it will not be soon, and will not be enough.

To more thoroughly address the toxins in fracking fluid: Between 2005-2009, oil and gas service companies injected 32.2 million gallons of diesel fuel in wells in 19 states [37]. Humans should never ingest diesel fuel, regardless of the concentration. Nor should they ingest hair-dye ingredients, anti-freeze, latex, copper compounds, aluminum, or a plethora of other chemicals that are consistently used in hydrofracking. Oil and gas companies explain though that the concentration and amount of chemicals they use in hydrofracking are "substantially diluted," so even if they were to enter an aquifer, which would never happen, the concentrations are not hazardous [38]. Plus, they would be diluted even further once mixed with the fresh water, so people have nothing to worry about. Well, there are a number of ways fracking fluids can, and have, entered USDW. A faulty or improperly installed well, especially in the initial steps of cementing between the casing and the hole after the first initial hole has been drilled can cause the fracking fluid to be forced directly into the aquifer. But more likely is the underground movement of fracking fluid through man-made or naturally occurring fractures in the shale that connect to USDW. Thus far, these fractures have not been completely tracked. So when a new well is drilled, while some of the natural fractures are accounted for, the technology has not been developed to trace every single natural fracture, and so it is impossible to determine if the fluid that is injected will travel through these fractures. And the fluid that is left in the rocks is not

[37] Zeller, Tom Jr. "Gas drilling Technique is Labeled Violation." *The New York Times,* January 2011.
[38] United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.

accounted for, remember the fluid that can go anywhere? It is likely to travel into those natural fractures and reach the USDW, undetected.

Complaints and reports from home-owners who claimed presence of anaerobic bacteria, greatly increased concentrations of methane, black coloration and petroleum scents, oily, cloudy, jelly-like grease in their drinking, bathing, and irrigation water as a result of hydrofracking wells near their property, who's pump houses have exploded because of the dangerously high levels of methane in their water, who have developed sicknesses after drinking their water, have generally gone unnoted[39]. Many oil and gas companies claim there are "no known cases" where surface or groundwater has been contaminated directly because of hydrofracking. Even after the EPA's involved study, where they did ask homeowners to report instances, and where they performed site visits, little has been done of reported problems. Often times, the claims are rejected as people find other natural causes for the issues to have arisen. Companies that have spills are fined small amounts of money, generally not held account to pay them on time, if at all. But, when someone can put a match to their facet and light the water on fire, something is obviously wrong.

Methane – the largest component of natural gas – is one of the non-CO2 gases contributing to global climate change. As mentioned above, methane leaks occur throughout the entire natural gas process from extraction to distribution [40]. Since CO2 is not emitted via natural gas use it is considered a clean fuel, but this idea disregards the threat methane has on the ozone. In low concentrations, methane gas in water is not harmful – it evaporates out of the water in

[39]United States Environmental Protection Agency. "Evaluations of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study." Washington DC, June 2004.
[40] United States Environmental Policy Agency. "Methane." Washington DC, April 2011.

fact, [41] but, this evaporation can be very harmful. The released methane can build up in a small or badly ventilated area and act as an asphyxiate or when mixed with air at a certain concentration, explode [42]. Levels of methane in drinking wells increase to dangerous levels when the wells are located near hydrofracking sites [43]. A recent study tested multiple wells in Pennsylvania and: "While most of the wells had some methane, the water samples taken closest to the gas wells had on average 17 times the levels detected in wells further from active drilling" – most of which were at levels considered hazardous by the U. S Department of Interior[44]. The test was able to identify the methane in the wells closest to the sites as thermogentic methane (as opposed to naturally occurring biogentic methane from biological decay) that is from the same rock layers aimed at for gas wells. [45] The industry though argues that thermogentic methane can be naturally present near aquifers and there is not evidence that the concentrations have anything to do with hydrofracking. Homeowners claim that methane levels increased only after a hydrofracking drill was installed. As far as the homeowners are concerned, explosive water wells are only one of their worries.

Mineral and land rights cause conflict between landowners and companies over the use of above ground locations for the extraction of below surface resources, especially when the companies tear-up and destroy the land in order to get the natural gas. The destruction of land through the hydrofracking processes is an environmental justice issue: disturbing the environment itself and as a result the well-being and survival of the landowners is compromised. Laying pipe for the transportation of natural gas can cover miles and miles of land, often times disregarding the land owners.

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[41] Wellcare. "Methane Gas and Gorundwater." March 2011.
[42] Wellcare. "Methane Gas and Gorundwater." March 2011.
[43] Lustgarten, Abraham. "Methane Increase Study." Duke University, *Propublica,* 9 May, 2011.
[44] Lustgarten, Abraham. "Methane Increase Study." Duke University, *Propublica,* 9 May, 2011.
[45] Lustgarten, Abraham. "Methane Increase Study." Duke University, *Propublica,* 9 May, 2011.

Chapter 4: Economics

America is too dependent on foreign oil. This dependency is hurting the U.S. environmentally, socially, and economically. The United States has a negative balance of payments and our addiction to oil is a huge component to this, and it does not seem to be ending any time soon. The country is sitting in the palm of cartels like Organization of Petroleum Exporting Countries (OPEC) because they are the only real suppliers and the demand for oil is so high, that they can set any price they want. Since America does not have a large amount of domestic oil, our dependency on foreign oil will only increase as we use ours up (to its entirety?). So we must lower our demand for oil, and thus reduce the cartel market [46]. Luckily, economists and politicians alike have realized this and are actively seeking ways to do so. Getting America off petroleum requires the exploration of other fuel and energy sources such as solar, wind, geo-thermal, nuclear, and natural gas. Although autarky is proven almost impossible, because in the modern world a country cannot produce enough for the demands of it's population – countries that have tried to do this in the past have failed – if the U.S could find a way to be autarkical in the energy field it would actually prove to be very beneficial. This would keep money circulating internally, create jobs for Americans, and may even turn our balance of payments around as the U.S. could eventually start exporting energy. It would also "smooth out" the business cycle, which again, is currently so dependant on other countries. For example, with China's rapid growth, they are importing more and more oil, which makes the overall prices of oil rise drastically, and the U.S. has no power to change this, so we must pay the

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[46] United States Environmental Protection Agency. "Reduce Oil Dependence Costs." United States Department of Energy, Washington DC 2010.

higher prices. Being completely energy independence would also help with the production of complimentary goods, giving a general boost to many other industries. Not to mention the commoditization of certain products. If solar panels, which are currently extremely expensive and thus not frequently utilized, become a commodity, their prices will go down and the demand will increase. But while this is true for solar or wind power, there is no way for natural gas to become a dominant fuel source in this country because although there are more domestic reserves than oil, eventually America would run into the same problems of foreign dependence for natural gas, as is currently the issue with oil. Russia sits on the largest natural gas reserves in the world, with 44,650,000,000,000 cubic meters, followed by Iran: 26,850,000,000,000 cubic meters, then Qatar then Saudi Arabia[47]. So, if America switched over to using natural gas as the main fuel, once their 50 years of gas were used up, they would need to depend on imports of natural gas as they do now for oil. Independence could certainly be achieved, but not through natural gas.

If done correctly this independence could also have a positive effect on the environment. Everything about oil is extremely harmful to the environment: the production destroys land, the large amounts of other fossil fuels it takes to produce and transport, the dangers of spills in transportation, not to mention the CO_2 that is emitted when it is burned. Using "clean energy" reduces these environmental impacts, especially the green house gas emissions, and the effects of climate change. But, if done too rapidly, without enough research and regulation, the effects could be detrimental. Because alternative energy is such a new product, putting it to use too quickly without enough knowledge about the subjects could cause major problems. Unfortunately, it appears like the natural gas industry is starting to go down this path.

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[47] Milton Beychok; C Michael Hogan. "Natural gas". Encyclopedia of Earth. Feb 22, 2012.

Companies that want to benefit from the new product are jumping in too quickly with drilling wells, building piping and overall trying to get claims on the resource before others can. Since natural gas is not renewable – there is a limited amount of it – so companies are trying to get immediate claims. The non-renewable component to natural gas makes it a "bridge fuel," a stand between (1) our use of oil and (2) our use of renewable energy efficient fuels. But, once we go through the 50 years or so that remains of reserves, then what? Natural gas is a short-term solution to a long-term problem.

This race for the resource does not allow time for proper regulations to be established, or it ignores regulations that are in place, or only half followed because they impede on production speed. But, those regulations are there for a reason, and so not following them results in detrimental accidents and harmful practices. The need for speed induces more accidents and mistakes as well – spills being the most obvious.

In West Virginia for example, companies that are not used to having strict regulation are hurry and get as much done as possible before they do have to account for their actions through permits and routine checks. Regulations that will slow them down and cost more money and resources (people for example) than unregulated production would. The results of this urgent rushing is huge trenches gutting through private property of poor land-owners who have no power in the matter.

In Colorado, the number of active wells increased from 22,228 in 2000 to 43,354 in 2010 [48]. As the market increases, the number of wells increases, the number and amounts of chemicals increases, the number of companies wanting a part of the profit increases, the number of people directly effected increases, the number of people indirectly effected increases. As

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[48] http://www.earthworksaction.org/files/publications/REPORT-Colorado-Enforcement.pdf

mentioned before, the increase in the number of wells does not mean the increase in the number of inspectors and thus unsafe – even if unintended – protocol and actions increase. Because of the size and location of hydraulic fracturing operation up to the point, it has gone unnoticed. Now that larger amount of people, with more political say are involved in the possible outcomes – i.e. all of New York City have to pay taxes for an 8 billion dollar water cleaning facility for their previously unaffected drinking water – people are starting to pay attention. It is devastating and humiliating that it took this huge increase in the market for people to finally examine hydraulic fracturing. The threat of hydrofracking is often times overlooked because those doing the examining leave out key aspects: "Many studies of gas drilling's economic effects have been based on input-output analysis, which does not account for embedded costs of environmental damage, general wear and tear to infrastructure, heath effects, and negative impacts of pollution on property values and key industries such as tourism, etc."[49]

Many of the economic accounts of hydrofracking impacts exclude negative externalities and so the prices projected do not reflect the actual cost. The primary example is in the greenhouse gases emitted through out the process. The cost of climate change for individuals, for businesses, for cultures, for nations, and for the world is too high if practices continue the way they are and has the potential of literally destroying the way the world functions. Other externalities in hydrofracking exist and go unaccounted for: air pollution results in health issues which include multiple extra costs – hospital visits, medicines or procedures, lifestyle changes, etc – which in turn require time, time that usually would be spent earning money, and the cycle continues to spiral down. Similarly with water pollution: if people can no longer drink their tap water because they can light it on fire, they will have to buy other water, or spend money (and

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[49] Bogok, Gusti. *Sierra Club*

time) on a lawsuit. Plus, the cost of clean-up of pollution is not taken into account and thus the companies that initially ignored these negative externalities suffer as a result. As far as these external costs are concerned, advocates of hydrofracking – usually the companies interested in the gas – do not account for them. And because the results of these negative externalities are yet to be realized and people do not know enough about them to begin with, they continue to believe the costs provided. It is challenging though to actually calculate these costs, there is nothing tangible to assess[50]. And how are the trade-of measured, what exactly is to be played off the benefits? For example, is the cost of private land destruction worth the benefit of being energy independent? What are the (positive) externalities of energy independence that are not being accounted for when compared to the negative externalities of hydrofracking? Eventually though, these external costs will add up and the economic viability of hydrofracking will be questioned; but it is important that now, before irreversible damage is caused, the actual cost of hydrofracking is comprehended and the process be monitored and kept to a smaller scale. One of the largest negative externalities is the unbalanced and disproportionate cost lower income people and future generations with have to pay. Many communities have been feeling the effects of the industry unfairly and unjustly for years.

Chapter 5: Environmental Justice and Human Rights (in Regards to Economics)

Echoing coal mining in West Virginia, or nuclear waste in Nevada, hydrofracking in the West and South has the potential (and already does?) to turn communities into “sacrifice zones,”

[50] Medved, Jon. Personal interview. 17 February 2012.

both environmentally and culturally. Sacrifice zones originated with the fallout of nuclear weapon factories: "a place that is written off for environmental destruction in the name of a higher purpose such as national interest." [51] Places that become dangerous or difficult for people to survive in – both physically and hypothetically via making a living – as a result of environmental destruction for national advancement.[52] This is a result of our capitalist driven society, where personal gain and national "advancement" dictate action. What exactly is the advancment directed to? What is the goal? Both Valerie Kulez in her book about Yucca Mountain and Rebecca R. Scott in her book about mountain top removal in West Virginia express the idea of sacrifice zones in regards to other environmental issues, explaining the effects large energy industry has on small, rural communities. An idea that has not yet been articulated for the land and people associated with hydraulic fracturing drills, although if the industry follows a certain "boom" could definitely be the fate.

As mentioned early, the location of natural gas reserves until now have been in small towns in the middle of nowhere Colorado, Wyoming, Louisiana, etc. Rural communities where poverty and poor education create a culture that is susceptible to industrial exploitation; where the landowners who sit on top of the natural resources are forced to sacrifice their personal well-being for the sake of a large, national concern. Here the competing interests of industry clashes with the local interests in cultural, economic, and environmental sustainability.[53] As Scott explains of the citizens in coal mining sites: "As prototypical white rural citizens, they are in some sense ideal Americans, but at the same time they are culturally and economically

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[51] Scott, Rebecca R. *Removing Mountains: Extracting Nature and Identity in the Appalachian Coalfields.* Minneapolis: University of Minnesota Press, 2010.
[52] Schneider, Keith. "Dying Nuclear Plants Give Birth to New Problem." *The New York Times,* 31 Oct. 1988.
[53] Scott, Rebecca R. *Removing Mountains: Extracting Nature and Identity in the Appalachian Coalfields.* Minneapolis: University of Minnesota Press, 2010.

marginalized, and the national/corporate interests they are asked to serve are not necessarily compatible with the survival of their communities and practices."[54]

The same can be said of communities affected by hydrofracking. Take for example the farmers in Colorado: an idealized lifestyle by the consumer driven, urban middle to upper class society swooning over: "A simpler life in harmony with nature," "an escape from civilization" where people are "self-sufficient and self-reliant.[55]" When in reality, the consumer driven, energy guzzling society marginalizes these people and fundamentally represses them. Dreams about these people get trumped by the reality of electricity and the increasing use of energy in every American's life, through phones, cars, computers, air-conditioners, heaters, or otherwise. And people do not realize that by being blasé about turning up the heat 10 more degrees results in someone's property being ripped up. Out of sight, out of mind, even with the sacrifice is happening right on American soil.

A disconnect is created as a result of the separation of human relationship to nature and a nonlinear notion of progress and development. The pressure of America's economic image and "success" in the world causes these sacrifice zones to be accepted as necessary and important. This is an example of Hardin Garrett's tragedy of the commons. Although Garrett's argument concerns the issue of overpopulation, his point resonates with natural resources. He refers to cattlemen in relation to an open pasture, and as each cattleman – growing exponentially – seeks to improve his own profit by adding another cattle to the land – remaining the same, not growing at all – he does so at the peril of the larger community, as the land will eventually be gone and not profitable to anyone: "the individual benefits as an individual from his ability to deny the

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[54] Scott, Rebecca R. *Removing Mountains: Extracting Nature and Identity in the Appalachian Coalfields.* Minneapolis: University of Minnesota Press, 2010. page 31.
[55] Jorgensen, Finn Arne. "What it Means That Urban Hipsters are Staring at Pictures of Cabins." *The Atlantic.* 12 March 2012.

truth even though society as a whole, of which he is a part, suffers."[56] The open pasture in this case is natural gas reserves and the cattlemen are the gas companies hoping to profit as a result of adding one more (many more) wellheads. But not only is the addition of wellheads taking away the "commons," – since society has pretty much already done that, and "closed the commons"[57] – it is now as if the pasture is scattered with people, and the cattle eat the grass which happens to be the roof of someone's house. And people who do not live on the pasture, who live in cabins with heating and bidets, see the people's roofs being eaten, but it is easier for them to ignore it, so they simply look out their other window at the view of Hollywood. As Hardin explains in regards to overpopulation: "It is fair to say that most people who anguish over the population problem are trying to find a way to avoid the evils of overpopulation without relinquishing any of the privileges they now enjoy. They think that farming the seas or developing new strains of wheat will solve the problem – technologically."[58] Replacing "population" with energy, this is currently applies to privileged Americans who would rather rely on an external technological solution – horizontally drilling? – to the crisis than admit their overconsumption habits are causing any problems, especially not such problems of other American's suffering.

Chapter 6: Proposed Solutions

While I do believe we need to become energy independent, I do not think natural gas is the best way to do so; the problems drilling for it cause seem larger than the problems it would solve. It seems like such a short-term solution: in the next 20 or so years, the natural gas

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[56] Hardin, Garrett. "The Tragedy of the Commons." *Science.* 13 Dec, 1968. Vol 162, no 3859, pp. 1243-1248.

[57] Hardin, Garrett. "The Tragedy of the Commons." *Science.* 13 Dec, 1968. Vol 162, no 3859, pp. 1243-1248.

[58] Hardin, Garrett. "The Tragedy of the Commons." *Science.* 13 Dec, 1968. Vol 162, no 3859, pp. 1243-1248.

industry would cause a tremendous boom in our economy, which would be sustained until…we run out of natural gas. The remains of which would be radioactive water, acres of destroyed land for pipes, drinking water that people can light on fire, burned fossil fuels for transportation, and nothing to heat our homes. This being said, perhaps if the proper regulations are in place, and companies proceed responsibly, self-regulate and keep updated on their technologies, without a huge push for control of the remaining reservoirs etc. the natural gas industry could be advantageous. It is a question of regulating the market and preserving the resource so it is not guzzled up and spit out again.

But this seems almost impossible. This is mainly because of the capitalist inclinations that have dominated economic systems world-wide for centuries. That is to say, developed countries desires to own more and more *things* – commodities – land and materials, the belief that this ownership will somehow better them, is the real problem. Even if regulations are established (the EPA is currently doing an in depth study scheduled to be released at the end of this year) the consumer mentality will find a way around them and fully exploit the resource. It is not about toxic drinking water, or land disturbances – these are merely the surface issues that manifest as a result of the deeper rooted mind-set that makes hydrofracking a problem. My proposed solution does not lie in regulations and laws – those have already been proven inadequate through people's distrust in government control. Regulations on diesel fuel used in frac fluid is a perfect example: the government made a requirement and then never followed up, and thus no steps were taken by companies – unless they were *self-imposed*. It is not about regulating resources, it is about changing the infrastructure and mindset in which those resources are extracted. Through a re-orientation of our values: considering all people as equals, viewing the earth not as a commodity to be exploited but as precious resource and without it, there will be no life, environmental justice will be served and economic stability can be realized in America.

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