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The Environmental, Social, and Economic Impacts of Hydraulic Fracturing, Horizontal Drilling, and Acidization in California

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THE ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACTS OF HYDRAULIC FRACTURING, HORIZONTAL DRILLING, AND ACIDIZATION IN CALIFORNIA

SUBMITTED TO

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BY

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Abstract

The oil extraction mechanisms of hydraulic fracturing, horizontal drilling, and acidization have recently spread throughout the state of California. This thesis explores and assesses whether federal and state legislation should approve of fracking operations in California after studying its effects on human health, the environment, and the economy. This thesis assesses the impacts of fracking; analyzes the role of current legislation and regulation; compares California fracking to fracking in other states and countries; and provides recommendations for future action.

Chapter 1: Introduction

Overview

The depletion of natural resources is inevitable and should be of genuine concern to the human race and to the nation's current political agenda. Of these natural resources, the depletion of fossil fuels such as crude oil and natural gas are most likely to have the greatest impact on humanity and the environment in a relatively short amount of time. The nation's high demand for crude oil and petroleum products will ultimately lead to complete exhaustion, unless new technological developments are created to extract more resources or to create comparable renewable replacements. However, this is not just a national issue, but a global one as well. In 2012, the world set a record for the amount of petroleum consumed, reaching 88.9 million barrels per day (bbl/d), consisting mostly of gasoline, diesel fuel, jet fuel, and heating oil. However, interestingly enough overall petroleum consumption has decreased in North America since 2005 most likely due to the economic crisis of in 2008 and recent improvements in motor fuel efficiency.[1] Though this may be a positive advancement in fuel-efficient technology and renewable resources, demand for oil and natural gas will continue to increase because the transportation sector of the U.S. economy continues to grow.

One way to increase crude oil and natural gas production is through horizontal drilling, hydraulic fracturing, and acidization (the combined three processes are hereafter referred to as "fracking") which have "greatly expanded the ability of producers to profitably recover natural gas and oil from low-permeability geologic plays—

[1] "World Petroleum Use," 2013

particularly, shale plays."[2] Simply defined, fracking is the "process of drilling down into the earth before a high-pressure water mixture is directed at the rock to release the gas or crude oil inside".[3] The fractures create new pathways that allow the release of crude oil and gas, which is then extracted through wells. Experimentation with this kind of drilling began in the late 19th century, but the modern day technique expanded to include large-scale production in the late 1980's in Texas' Barnett Shale. Since then, hundreds of other oil and gas drilling companies have aggressively entered the fracking market after observing the profitability in shale plays. Furthermore, shale gas has recently been classified as a "game changer" in the U.S. natural gas market.[4] The prospect of being able to greatly increase oil and gas production appeals to the industry, the government, and the people.

The impact of fracking on the U.S. oil market has been widely studied and explored in the northeast region of the country and in Texas, but not much has been investigated and reported about how California would be affected by shale gas and oil production until very recently. The largest play in the nation, estimated to contain about 64 percent of total shale oil, is the Monterey Shale, which stretches from Southern California to mid-state. The area is made up of about 1,752 square miles and estimates state that it could produce up to 15.42 billion barrels (bbl) of recoverable oil, a number predicted by the depth of the shale, the thickness, the porosity, and the total organic content.[5] Because of California's reliance on imported oil and the increase in demand, fracking provides the opportunity to exploit native resources, possibly stimulating the state's, and even the

[2] "Review of Emerging Resources," 2011
[3] "What is Fracking?" 2013
[4] "Review of Emerging Resources," 2011, 51
[5] "Review of Emerging Resources," 2011, 75

nation's, economy. However, because the vast impacts of fracking on human health, safety, the environment, and the state's economy are largely unknown, fracking operations should cease and no new operations should be implemented until an expansive and in-depth study is conducted by regulatory agencies.

Due to the widespread and adverse impacts of fracking in California, drilling sites should cease to continue operations until there is more transparency by the oil and gas companies and its effects on the environment, human health, and economy are more meticulously studied. To date, evidence has shown that fracking releases harmful emissions, polluting the air and local water sources and contributing to increased health problems to nearby residents, such as respiratory illnesses and lung cancer. Offshore fracking facilities are also dumping thousands of gallons of wastewater into the ocean, severely threatening the vitality of marine life. In addition, fracking uses thousands of gallons of water, a practice that is not sustainable in California's current severe drought. Water competition among farmers and local operators is also increasing and causing hostility. Additionally, the recent series of Southern Californian earthquakes have turned the attention to look at fracking's relationship with seismic activity. Several studies have demonstrated that the closer a wastewater injection well is to an active fault, the greater the risk of creating an induced earthquake. Another area of concern is the transportation of oil into the state by pipeline or railroad due to the risk of potential explosions and pipe leakage, which would have devastating effects to the environment. The fracking process itself is dangerous, thus compromising the health and safety of industry workers. There have been dozens of documented deaths and injuries on site, as well as links to diseases such as silicosis.

As with any large-scale operation, it is necessary to analyze the economic impacts that fracking the Monterey Shale would have on the state of California. A preliminary study predicted that the Monterey Shale contains upwards of 15 bbls of crude oil, a number economists have used to forecast the potential for economic growth through increased employment opportunities and state gross domestic product (GDP). However, a follow-up study has demonstrated that the amount of recoverable oil is lower, at about 13 bbls. Though this number is still significantly large and demonstrates potential for economic growth, the methods of gathering these estimates are highly flawed, thus there should be skepticism of the highly optimistic numbers. Estimates were made without considering the complexity of the geological formations that have never been drilled into before. Thus, new techniques and technologies may have to be developed, possible costing more than the economic benefit of extracting the oil. Furthermore, fracking also has adverse economic effects such as damaged infrastructure, reduced property values, and the cost of remediating wastewater.

Federal and state legislation need to be amended to include fracking and control the activities of oil and gas companies. California regulatory agencies, such as the Bureau of Land Management, Environmental Protection Agency, and South Coast Air Quality Management District, need to play a direct role in overseeing fracking operations and ensuring the compliance of the companies with previously laid out guidelines and requirements. Not enough is being done by Governor Jerry Brown's administration to ensure safe practices and exposing all aspects of the process and the industry to the public. Thus, because of the negative impacts, economic uncertainties, and lack of

regulation, fracking should cease to continue in the state of California and the Monterey Shale should remain unexplored until further in-depth studies can be conducted.

The Past, the Present, & the Future of Fracking

The history of oil production in California dates back to the early 16th century when exploring Spaniards discovered Native Americans collecting a thick oil known as asphaltum, formed from natural seeps in the earth's surface. The discovery of these seeps continued across the state as more explorers arrived in the 1850's and 1860's, with the majority of exploration occurring in Southern California counties. Interest in oil increased after the discovery of illumination using kerosene in Pennsylvania. Andreas Pico was the first Californian to use oil as an illuminant in 1850, arguably causing another kind of Gold Rush, a rush for oil. The first record of commercial oil refining is attributed to G.S. Gilbert in Ventura, California, producing about 300 gallons of refined oil weekly. A few years later, workers began to dig tunnels in order to allow the flow of oil, which became the most successful method of producing oil in California up until 1997 when the last tunnel was plugged.[6]

Successful oil drilling began in the late 1860's in Humboldt County areas, but began to slow down a few years later due to Pennsylvania's abundant oil production, which led to most of California's oil being imported at more competitive prices from out of state. However, important progress was still being made, exemplified through the Pico 4 well, the first commercial oil well in California, and the Pioneer Oil Refinery, which was the destination site of the first two-inch pipeline. Two great discoveries for the oil and natural gas industries were discovered in 1890: the Midway Sunset Field in Kern County and the

[6] "The History of the Oil Industry," 2014

Coalinga Oil Field in Fresno County. However, technology was not yet advanced enough for large-scale production. A few years later another great phenomenon was discovered: oil gushers, which are uncontrolled releases of crude oil from a drilled well. As with the discovery of large oil fields, there was no technology to store the vast amounts of oil released by the first few gushers, thus oil merely spilled out and contaminated local surroundings. Soon after, the Los Angeles City Oil Field led to oil over production, resulting in a dramatic decrease in price per barrel. The oil boom continued with the discovery of the McKittrick Oil Field, the Kern River Oil Field, and the Midway Area Oil Field. At the turn of the 19th century, the state was producing 4.3 million barrels of oil a year. Just five years later, that figure rose to 34 million barrels.[7]

The most famous gusher, Lakeview, began in March of 1910 and continued for 18 months in the Midway-Sunset Oil Field. By the end of this period, 8.2 million barrels of oil had been produced, the most oil ever produced in the United States from a single oil well. The next few years brought the discovery of Elk Hills, Lost Hills, South Belridge, Huntington Beach, Long Beach, and Kettleman Hills Oil Fields, further increasing California's oil production. After the 1930's no major oil production fields were discovered except for several offshore fields in Santa Barbara County, which were shutdown after a large and disastrous spill. Nothing significant occurred in California's oil industry until the 1980's when oil production reached an unsurpassed high. However, production then began a continuous decline, by about 47%, due to the world's collapse of oil prices. Furthermore, California's oil is of lower quality when compared to other

[7] "The History of the Oil Industry," 2014

produced oil and has higher transportation and refining costs.[8] Figure 1 below illustrates the patter of U.S. oil reserves, which mimics the path of California's reserves.

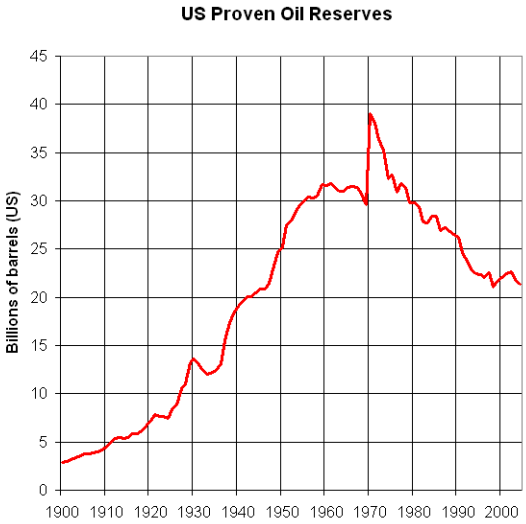

Figure 1. Oil reserves in the U.S. throughout the 20th century. California oil reserves followed a similar path (Source: Wikimedia Commons).[9]

As a result of California's struggling economy, the energy industry is suffering as well. Since 1985, crude oil production has been cut in half and the state imports the majority of its oil. Furthermore, the Los Angeles Economic Development Corporation predicts that in-state oil production will decrease by about 40% in the next six years.[10] As California's population continues to grow, so does energy demand, thus new fuel sources are vital to sustain the growth. The California Council on Science and Technology predicts that by 2050, the U.S. will be using twice the amount of energy that it did in 2011, increasing statewide energy use by 1.6% annually.[11] The four main energy-

[8] "Oil and Gas Production," 1-7

[9] "US Proven Oil Reserves," 2006
[10] Freeman et al., 2008, 25
[11] Long, 2011, 41

consuming sectors in California are residential, accounting for 18.7%; commercial, accounting for 19.2%; industrial, accounting for 22..6%; and transportation, accounting for the majority at 29.6%. The U.S. Energy Information Administration's (EIA) 2012 Annual Energy Outlook reports the variations in the type of energy used per each sector with commercial, residential, and industrial sectors relying mostly on natural gas; however, the transportation sector energy use is 99.2% petroleum.[12] Although California leads in energy conservation practices and Greenhouse Gases (GHG) mitigation techniques, the inevitable population and economic growth will result in a greater need for energy, which cannot be sustained with current natural gas and crude oil production. The method needed to fill this "energy gap" is under great debate, with fracking being a viable contender.

To understand California's need to expand its energy sources, it is important to look at where California currently gets its energy from: over two-thirds of the state's energy sources are imported, 21% are domestic oil and gas, 4% are nuclear power, and 8% are renewables. Figure 2 below demonstrates California's energy sources in 2010.

[12] "Annual Energy Outlook," 2012

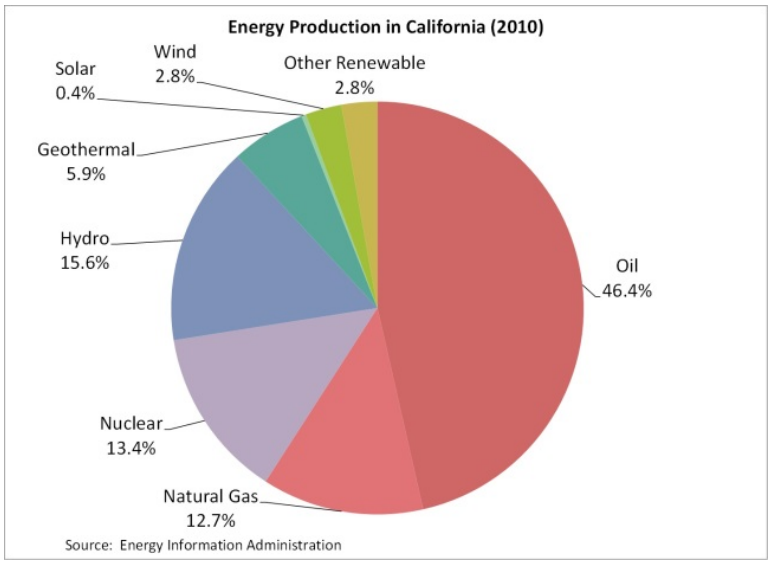

Figure 2. California's energy production sources in 2010 (Source: Oil Independents).[13]

California imports most of its energy sources because of the decline in domestic energy production, not because of limited reserves, refining technology, or lack of renewable energy development.[14]

A 2011 report by the California Energy Commission (CEC) verifies that California's crude oil production has decreased by 47% between 1985 and 2010, resulting in foreign imports increasing by 16% annually between 1986 and 2006. Additionally, the future does not suggest that foreign oil imports will decrease or that in-state crude oil production will increase, but rather that California's crude oil production will decrease by about 2.5% annually for the next 20 years.[15] Although California has made significant steps in establishing a successful renewable energy market, the majority of these sources go to electricity production and barely any are used in the transportation sector, which instead heavily relies on oil. Furthermore, though alternative fuel vehicles such as hybrids,

[13] "The Story of California Crude," 2014
[14] "The Story of California Crude," 2014
[15] Kavalec, 2011, 16

electric, and natural gas using, provide a possible solution in diminishing reliance on petroleum, they only make up less than 3% of the number of vehicles on the road in California.[16]

The Basics of Fracking

Fracking is the process of injecting fluids under high pressures to crack underground rocks in order to release oil or gas, after a hole is drilled at the site. The creation of fractures in the rock increases the rate of fluid production, thus allowing the extraction of more oil and gas. The main materials used in fracking fluid are water and sand, with the addition of 750 other chemicals. The exact mixture depends on the condition of the specific well. These chemicals, which include acids, gellants, corrosion inhibitors, friction reducers, clay controls, crosslinkers, scale inhibitors, breakers, iron controls, and biocides, help limit bacteria growth and prevent well casing corrosion. Each chemical additive serves to ensure that fracking is conducted in an efficient and effective manner. For example, friction reducers allow the fracturing fluid to be pumped into the rock at a higher rate and reduced pressure, biocides inhibit microorganism growth, oxygen prevents metal corrosion of pipes, and acids eradicate dirt and mud damage around the drilling site. Experts involved in oil and natural gas drilling predict that ten years from now, over half of the wells in the U.S. will rely on fracking in order to continue operating. This process allows older oil and natural gas fields to continue producing resources, thus extending the lifetime of oil and gas producing sites. It also allows for the

[16] "Alternative Fuel Vehicles," 2014

extraction of oil and gas from formations that were previously believed to be impossible to extract, such as tight shale formations distributed across the nation.[17]

The technique of matrix acidization ("acidizing"), is the most likely contender for oil extraction and production in the Monterey Shale. Acidizing involves injecting high volumes and concentrations of hydrofluoric acid into oil wells in order to dissolve the rock formations, allowing oil to freely flow up through the well. Oil companies have found that acidizing may be the most effective in the Monterey Shale because the rock formations are complex and have low permeability; however, many have questioned the safety of using ambiguous concentrations and volumes of hydrofluoric acid, the most dangerous chemical used in industrial processes. To date, there have been two documented industrial hydrofluoric acid leaks, one in Texas and one in Korea that killed 5 workers.[18] Acidizing produces much of the same effects and impacts as fracking, thus when referring to "fracking" in the rest of this analysis, "acidizing" is implicitly included.

California's fracking technique is different from that of other states' because the goal is to extract heavy crude oil, as opposed to natural gas or light crude oil. Heavy crude oil has a high viscosity, low turbulence, and must be extensively refined in order to be the most beneficial. The American Petroleum Institute (API) has a set standard for measuring petroleum's density, called the API gravity, and is used to categorize oil as light, medium, heavy, or extra heavy. Light oil has an API of greater than 31.1 and has the greatest market value. On the other hand, heavy oil has an API of less than 22.3, meaning that in order to become marketable, it needs to be refined.[19] Not only does fracking for

[17] "Hydraulic Fracturing: the Process"
[18] Collier, 2013, 3
[19] "Gas Prices are too High," 2013

heavy oil requiring injective fluids at higher pressures, potentially causing more geological damage and source water contamination, but also requires a more expensive refining process.

Fracking is done in a different way at each specific site because each formation varies in its condition. The process is fundamentally the same in all situations, but the sequence changes according to the particular drilling site. The basic process consists of an acid stage, a pad stage, a prop sequence stage, and a flushing stage. During the acid stage, thousands of gallons of water are mixed with a dilute acid in order to diffuse wellbore debris and provide a channel for other fracturing fluids by dissolving carbonate minerals. The pad stage fills the wellbore with a slickwater solution, which opens the rock formation and facilitates the flow of proppant material—a solution made of sand and ceramic material that opens the created fractures. The prop sequence stage, made up of several smaller substages, uses proppant material to keep the fractures open. The last part, the flushing stage, washes out the excess proppant material from the wellbore using a large volume of fresh water. Fracking is performed horizontally at depths less than 2,000 square feet in order to create fractures that cause the least amount of stress on the formations. As depths increase past 2,000 square feet, internal stress and pressure increases, meaning that horizontal fracturing is the least stressful aspect of the process. Thus, fracturing becomes oriented in the vertical direction. The size of the fracture is controlled by two conditions: the confining zone and the volume, rate, and pressure of the fracturing fluid. The confining zone, or formation, limits the vertical growth of the fracture because it is either strong enough or not strong enough to handle the pressure and

volume of injected fracturing fluid. Fracture length can also be influenced by natural faults or preexisting fractures.[20]

Fracking is not a new phenomenon. The idea of injecting acid into the ground to stimulate oil production was first pioneered in the early 1930's. It later became known as "pressure parting" because it created a fracture that never completely closed due to acid etching, which left a channel for oil to flow out of dramatically increasing productivity. The first known well stimulated to produce natural gas was in 1947 in Grant County, Kansas by Stanolind Oil and Gas Corporation and although it did not produce a dramatic increase in oil production, it was a necessary step in the right direction. Two years a later a patent was granted to Halliburton Oil Well Cementing Company to perform commercial fracturing in Oklahoma and Texas. During the first year of implementing fracking practices, 332 wells were developed, increasing production by about 75%. Over the next few decades, the United States' oil production significantly increased as a result of expanding fracturing jobs.[21]

There are currently ten counties in California that have known and ongoing fracking operations: Colusa, Glenn, Kern, Los Angles, Monterey, Sacramento, Santa Barbara, Sutter, Kings, and Ventura. There are also several offshore fracking facilities in the Santa Barbara Channel. More than 80% of the oil and gas wells in California are owned by members of the Western States Petroleum Association (WSPA) and it is estimated that they operated at least 650 fracking well sites in 2013, a huge increase from the 78 wells three years prior.[22]

[20] "Hydraulic Fracturing: the Process"
[21] Montgomery and Smith, 2011, 27-28.
[22] "Fracking in California"

Chapter 2: Fracking Owners & Operators

Occidental Petroleum Corporation (Oxy) is one of the nation's largest natural gas and oil exploration and production companies, and is currently California's top oil producer with regards to gross-operated barrels of oil. Additionally, Oxy has operations in over 125 state oil fields. It acquired the giant area of Elk Hills in Kern County in 1998 and since then has continued developing in California fields using fracking techniques. Elk Hills is one of the largest oil and natural gas fields in the nation and produced the first California oil from a shale play. Oxy also has an 80% stake in the oil operations in Wilmington Oil Field in Long Beach through its subset company, Oxy Long Beach Inc. Oxy acquired THUMS Long Beach Company in 2000, which operates the offshore portion of the Wilmington Field and Tidelands Oil Production Company, which operates the onshore portion. THUMS owns and operates four man-made islands in the Long Beach Harbor, designed to blend in with the local coastal environment and covers between ten and twelve acres. Six years after acquiring THUMS, Oxy acquired Tidelands Oil Company to operate the western portion of the field.[23] Since 2011, Oxy has fracked 215 wells.[24]

Venoco Inc. operates onshore and offshore facilities in California. Onshore, its operations are located at the Beverly Hills West Field in Beverly Hills, which covers 0.6 acres next to Beverly Hills High School, and at the Santa Clara Avenue Field in Ventura County. The company also operates three offshore facilities in the Santa Barbara Channel: Platform Grail, Platform Holy, and Platform Grace. Venoco Inc. works in the Sacramento Basin at the Willows and Grimes Field, the Sacramento Delta Fields, the

[23] "Oil and Gas: Long Beach"
[24] Martin, 2013

Dutch Slough Field, and the Union Island Field.[25] Since 2011, Venoco has fracked 20 wells.[26] In February 2014, the Environmental Defense Center (EDC) released a report accusing Venoco Inc. of using wellbore matrix acidization at Platform Grail. This drilling technique involves injecting chemicals into underwater rock, the wellbore, in order to increase permeability and consequently, the productivity of the well. However, Venoco Inc. denied the accusations, claiming that acid is used at the site to clean the wellbores, but the EDC warns of the distorted line between using acid for cleaning versus using it for stimulation. The bigger concern of EDC's investigation is the lack of regulation over environmental concerns.[27] The use of acid to stimulate well production can lead to detrimental environmental impacts.

Aera Energy LLC is a jointly owned company by Shell and ExxonMobil and produces over 25% of California's oil and gas. The center of Aera's operations are in the San Joaquin Valley in Kern County, which produces the most oil of any county in the nation. One of its five drilling operations is the Belridge Oil Field, covering 22 miles in length and 2.5 miles in width and producing more than 81,700 barrels of oil equivalent per day. The Coalinga operation in Fresno County covers 15 square miles and produces about 7,000 barrels of heavy crude oil equivalent each day. Aera Energy is also the largest operator in the Midway Sunset Oil Field in Kern County, which is one of the top ten producing oil fields in the U.S. producing 26,000 barrels of oil equivalent per day collectively through the North and South fields. Another one of Aera's fields is San Ardo, a field covering seven square miles about 30 miles north of Paso Robles. The field

[25] "Where We Work"
[26] Martin, 2013
[27] Ricapito, 2014

produces about 9,200 barrels of crude heavy oil daily. Lastly, Aera owns an oil and gas operation in Ventura County, which produces 13,900 barrels of crude oil a day. In each of Aera Energy's five operations, oil is sold on the premises and then transported to California refineries for further processing.[28] Since 2011, Aera has fracked 779 wells in California.[29] In December 2004, Farmer Fred Starrh sued Aera energy is a high profile lawsuit for contaminating his groundwater and restricting his farming opportunities because the land could not be irrigated properly. In 2009, the local Bakersfield jury awarded Starrh $8.6 million, but he appealed the sentencing hoping to achieve punitive damages. The case is still ongoing.[30]

Freeport McMoRan Oil and Gas (FCX) is a division of the natural resource company Freeport-McMoRan Copper & Gold Inc. FCX operates onshore in the Los Angeles Basin and the San Joaquin Basin, as well as in an area just outside San Luis Obispo called Arroyo Grande. The company operates offshore as well in Point Arguello and Point Pedernales, both located in the Santa Maria Basin.[31] The residents of FCX's West Adams' Murphy operation, located near the University of Southern California (USC), have started an effort to stop the fracking site in order to protect their safety and the environment. The formed organization, CoWatching Oil LA, wants more transparency and regulation in LA's natural gas and oil industries and ultimately wants a ban on urban drilling procedures.[32]

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[28] "Our Operations", 2011
[29] Martin, 2013
[30] Barrios, 2013
[31] "Oil and Natural Gas: California"
[32] Monte, 2014

Chevron first discovered oil in California 130 years ago in Los Angeles and continues to be the state's top oil and gas producer, producing 165,000 barrels of oil and 83 billion cubic feet of natural gas each day. Along with owning oil-producing fields, Chevron operates the two largest Californian refineries, one in Richmond and one in El Segundo. Furthermore, the company owns and maintains over 1,000 miles of Californian pipeline, delivering oil to major airports and other facilities. The majority of Chevron's operations are in the San Joaquin Valley—the Kern River Field, which covers 16 square miles, the Temblor Thermal Area, and West Central California, which includes Coalinga, Lost Hills, Kettleman Hills, and San Ardo.[33]

Independent, private energy companies have also proposed and begun fracking projects. One of these companies, Santa Maria Energy (SME), focuses its operations in the Monterey Shale in Santa Barbara and extracts oil from diatomite, a naturally produced, soft, and porous sedimentary rock consisting of ancient deposit layers of single cell marine animals, diatoms. The company's oil drilling and production plan (ODPP) calls for the installation of 136 oil wells, two steam generators, connecting pipelines, and oil processing facilities. The project will cover 32 acres of the state-designated Orcutt Oil Field. The ODPP will use a different kind of unconventional well-stimulation technique, cyclic steaming. Cyclic steaming involves a generator pumping large amounts of steam into the ground in order to extract oil through oil wells. The steam is generated using recycled water. The construction of the 110 new wells will require 300,000 gallons of water daily, thus Santa Maria Energy has plans of constructing an 8-mile long pipeline from the Laguna County Sanitation District wastewater treatment facility. The company

[33] "Where We Operate"

emphasizes that emissions would be reduced because of the elimination of thousands of truck trips. Furthermore, the pipeline will serve farmers, parks, and golf courses.[34]

Santa Maria Energy plans to pursue $1.2 billion of oil reserves from an estimated 48 million barrels in more than 7,700 drilling sites, pumping as much as $114 million into Santa Barbara County. The company plans to drill 110 new wells in the North near Orcutt, in addition to 26 already existing ones, and has no plans to use fracking, but rather it plans to use a secondary enhanced oil recovery technique called cyclic steaming. Santa Maria will be able to expand its drilling operations due to its upcoming merger in June with Hyde Park Acquisition Corp. II. The merger will make $40 million available to begin the new development projects.[35]

[34] Hartnett, 2014
[35] Nellis, 2014

Chapter 3: Urban & Rural Fracking Operations in California

Fracking has been California's best-kept secret for the past several decades. However, it is gaining transparency and media coverage as more and more affected communities are voicing their concerns and have begun petitioning for California to pass a moratorium on state-wide fracking. Fracking's detrimental effects have impacted Southern California residents the most. For example, AllenCo Energy Inc. has an oil drilling facility located in University Park, Los Angeles, in close proximity to a charter school, a Los Angeles Unified School District high school for disabled adults, Mount Saint Mary's College, the University of Southern California (USC), and several other residential buildings. The facility produces more than 80 barrels of oil daily. Residents have continuously complained about the strong sulfur and gas odors that cause frequent headaches, nausea, dizziness, confusion, and sleeplessness and have adamantly campaigned for the shutdown of the facility.[36] The community's complaints at a town hall meeting to the South Coast Air Quality Management District (SCAQMD) in the fall of 2013 prompted an investigation by the EPA, in which the facility was found to be in violation of Federal legislation, namely the Clean Air Act and the Clean Water Act. The organization's regional administrator for the Pacific Southwest, Jared Blumenfeld, issued a statement indicating that AllenCo Energy Inc. had failed to maintain a safe operation, thus putting neighboring residents at risk of health and safety. He also promised residents that the EPA would work hard to protect the surrounding communities by "ensuring that AllenCo complies with Federal environmental laws."[37] The violations by the EPA found that AllenCo had failed to inspect various pieces of equipment, to test methane and flame

[36] "University Park Residents," 2013
[37] "University Park Residents," 2013

detectors appropriately, to accurately diagram the facility, to compile a complete Spill Prevention, Control, and Countermeasure (SPCC) plan in time, to properly train personnel, to keep an emergency contact list of agencies in case of spills, and to keep a record of completed inspections.[38] As a result, the facility was forced to cease operations in November 2013 until it responded to the violations. As of April 2014, the operation has not reopened.

In early January, Los Angeles City Attorney Mike Feuer filed a lawsuit to prevent AllenCo Energy Inc. from reopening the South LA facility due to its deliberate disregard of issued violations found by both the EPA and the SCAQMD. The complaint states that "no community should have to live this way, with windows shut, children kept indoors to protect their health, and neighbors seeking relief from intolerable conditions"[39] and states AllenCo's owner Pete Allen and its Vice President of Operations Timothy James Parker as the defendants in the case. The company has dramatically increased its oil production since 2009, thus causing various other agencies like the Los Angeles Fire Department and water quality inspectors to file their own complaints.[40] AllenCo has been able to continue its hazardous operations because of the miscommunications amongst agencies and lack of action taken by the agencies. The facility sits on land leased by the Archdiocese of Los Angeles and many activists have called on the Catholic community's involvement in ceasing all fracking activity in the area. One young girl went as far as to make a video pleading to Pope Francis for his help, demonstrating the increasing desperation of the situation.

[38] Mogharabi, 2014
[39] Sahagun, 2014
[40] Sahagun, 2014

Fracking is also heavily occurring in the Inglewood Oil Field in Baldwin Hills, neighboring a community of over 300,000 residents. The nation's largest urban oil field lies in areas of Culver City, Los Angeles, and Inglewood. The field is operated by Texas-based company Plains Exploration and Production Co (PXP) and uses high volume hydraulic fracturing (HVHF) due to the field's limited areas and harder frack formations.[41] Culver City residents have expressed concerns about fracking following the passage of recent legislation, Senate Bill 4 (SB 4) because although it calls for a public health impact study of fracking, it still allows oil companies to continue fracking during the process. Concerned residents have come together to form FrackFree Culver City, a campaign dedicated to ban all fracking activities in Culver City and the Inglewood/Baldwin Hills Oil Field. The campaign cites the following fracking concerns: the city's close proximity to the San Andreas Fault, the Baldwin Hills situation on geologically unstable land, the new experimental fracking procedures being used have caused known earthquakes in other locations, the possibility of oil spills or explosions, exposing the community to toxic odors and emissions, lack of regulation transparency, and overconsumption of water that California does not currently have.[42]

The third largest oil field in the U.S. with regards to area and total oil production is located in Long Beach's Wilmington Oil Field, producing about 3 bbls of oil since 1932. The field contains 1,300 active wells. Tidelands Oil Production Company operates the field in the west and Occidental Long Beach Inc. (OLBI) in the east. Most of the extracted oil comes from the offshore portion of the field, consisting of four artificial islands designed to blend in with the local surroundings. Further down the coast is

[41] "Fracking in Culver City," 2013
[42] "Fracking Fact Sheet," 2013

another drilling site, the Huntington Beach Oil Field, also operated by Occidental Petroleum. The field produces about 2 million barrels of oil annually, both from onshore and offshore production. Fracking sites are also spread throughout Southern California, sometimes in unsuspecting locations. These locations include the Cheviot Oil Field in Century City, the Beverly Hills Oil Field, the Salt Lake Oil Field that stretches from Beverly Hills to the Wilshire District, the Las Cienegas Oil Field stretching from La Brea to downtown L.A., the Los Angeles Downtown Oil Field, the Montebello Oil Field, the Santa Fe Springs Oil Field, the Whittier Oil Field, the Sansinena Oil Field next to La Habra Heights, and the Brea-Olinda Oil Field in northern Orange County.[43]

Offshore fracking has been gaining momentum off the California coast, mainly in the Santa Barbara Channel and Long Beach Harbor. Offshore fracking has been used commercially for the past several decades and uses techniques similar to onshore fracking to stimulate wells on the ocean's surface floor. In February 2014, federal regulators approved of three new offshore fracking operations in the midst of a controversy between the U.S. EPA and oil companies fracking offshore, an issue that arose from the uncertainness of the exact amount of fracking that occurs off the coast. In August 2013, the Associated Press discovered and reported 200 various undocumented fracking sites, leading to a state investigation by the California Coastal Commission. The lack of state regulation and involvement in the permitting process is thought to be a huge institutional and authoritative failure. As the State Lands Commission finds more instances of offshore fracking, confusion has arisen over who exactly is in charge of monitoring and regulating offshore fracking techniques. As a result, the U.S. EPA has published a

[43] Preston, 2013

requirement for Southern California oil and gas companies fracking off the coast to report discharged chemicals to the state of California.[44] The figure below illustrates the locations of offshore oil rig platforms in Southern California.

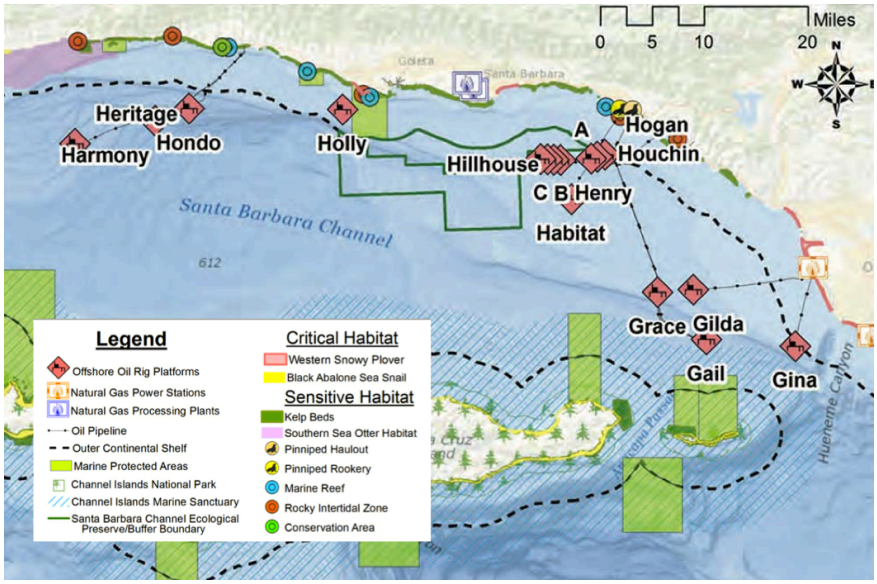

Figure 3. Offshore fracking sites in the Santa Barbara Channel (Source: CAFrackFacts).[45]

[44] Change & Dearen, 2013
[45] "Where is Fracking Occuring?" 2013

Chapter 4: National & Global Fracking Operations

Texas

Texas contains five major shale gas plays and has set an important example in developing new fracking techniques. A shale gas play refers to a "geographic area, which has been targeted for exploration due to favorable geoseismic survey results, well logs, or production results from a new well in the area."[46] The largest play, the Barnett Shale, was one of the first to be exploited between 2005 and 2007. Texas' history of oil and gas production dates back to the mid-19th century and the state has consistently been one of the world's top producers. In 2009, Texas accounted for 30% of the country's natural gas production, but as the source of natural gas changes, the state has changed its production mechanisms in order to continue leading U.S. natural gas and oil production. Shale production is increasing annually at a steep rate, thus making Texas an important player in domestic U.S. shale oil and gas production. In 2009, Texas produced 57% of the shale gas in the nation, and the numbers have only increased from there. The richness and abundance of natural gas and oil, along with vast amounts of companies to exploit these resources, are the driving factors in Texas's leadership in fracking.[47]

There is no direct control over shale oil and gas production and fracking techniques in Texas due to lack of a regulatory climate and an administrative structure that supports oil and gas production above all other issues and matters. Unlike the majority of other states, Texas does not have a centralized department or government branch for overseeing environmental regulations. The state is widely known for its lack of concern for preserving the environment and for its governor's, Rick Perry, staunch opposition to

[46] "What is a Shale Play?" 2010
[47] Rahm, 2011, 2976

the EPA. The agency supposedly in charge of Texas's pollution and environmental issues, the Texas Commission of Environmental Quality (TCEQ) has had disagreements with the EPA in the last several years, beginning in 2010 when the agency discovered the TCEQ's lack of implementation of the Clean Air Act and the state's refusal to enforce GHG regulations. Not surprisingly, Texas leads the nation in GHG emissions. As a result of the situation in Dish, Texas, the EPA has pleaded that the state carefully analyze and consider the harmful effects of air emissions from the Barnett Shale before continuing to frack at such an exponential rate.[48]

The city of Dish lies on the Barnett Shale, the main oil and gas production sites in Texas. Residents have had to endure loud noise, strong odors, constant vibrations, and violent illnesses, causing various organizations to sample the local air quality to determine its exact components. Elevated levels of carbon disulfide and methyl ethyl disulfide were detected, which cause respiratory difficulties, along with benzene, xylenes, and naphthalene, which are known human carcinogens. The Texas Department of State Health Services decided to conduct their own study by analyzing blood samples from Dish residents and found no significant difference in chemical levels from the rest of the U.S. population. However, the study only used one sample per resident and did not take into account how temperature changes, wind-speed, or other site variations could affect these levels.[49]

Another Texas government agency, the Railroad Commission (TRC), has also found itself disputing with the EPA. The TRC's main responsibility is regulating oil and gas industries, while maintaining safety and conservancy of natural resources. However,

[48] Rahm, 2011, 2979
[49] Schmidt, 2011, a351

at the same time it also endorses advancing economic development, thus promoting the operations of the oil and gas industry instead of promoting environmental conservation. Similarly to TCEQ, the TRC did not properly enforce the Safe Water Drinking Act, thus creating significant conflict amongst the agencies. The EPA issued an order of endangerment after the discovery of flammable drinking water, at last winning the ongoing battle with the Railroad Commission. Another regulatory issue that affects means of fracking is water quantity, since it requires millions of gallons a year to keep up with production. This raises concern because of Texas's dry climate, but it has not prevented fracking from continuing and expanding. Furthermore, the law in Texas allows private gas pipeline companies to instill lines wherever they see fit, disregarding property and ownership rights. [50] The lack of regulation and provisions have made Texas an attractive environment for oil and gas producers to take advantage of hydraulic fracturing and exploit the vast amount of resources that exist in the shale plays. It also highlights the need for stricter regulation in California, or agencies will inevitably find themselves in conflict.

Pennsylvania

Pennsylvania contains a large proportion of the Marcellus Shale, a black shale formation that contains vast amounts of natural gas (up to 1 trillion cubic feet) and crude oil. There are currently 6,391 active wells maintained and owned by 59 different operators.[51] The U.S. natural gas boom is credited with beginning with the Marcellus Shale, which is spread throughout Pennsylvania, West Virginia, Ohio and New York; however, Pennsylvania has received the most attention and media coverage in part

[50] Rahm, 2011, 2889.
[51] Amico et al., 2011

because of a 2010 documentary, *Gasland.* The film depicts the struggle that local communities face in allowing gas companies to frack on their land or in close proximity to their land. Many Pennsylvanian residents have to decide if the large sum of money offered to them from the companies for mineral rights is worth the risk of living with contaminated water and polluted air, both of which can lead to serious health effects. The documentary, produced by Josh Fox, focuses largely on the town of Dimock, where interviewees complain of undrinkable water that severely affects human and animal health. Interviewees complained of murky, brown tap water that was often times flammable. Furthermore, when residents complained to the oil and gas companies, the received response was that there was nothing wrong with the water that could be attributed to natural gas and oil production.[52]

As with California, there are many positive projected economic impacts of increasing and expanding drilling of the Marcellus Shale. The Pennsylvania College of Technology estimates that if drilling continues at its current pace, up to 10,500 jobs could be added within five years, most of them blue-collar jobs. The increased state economic activity would also have trickle down effects—royalties from gas companies would benefit landowners directly, thus increasing local spending and stimulating the local economy. However, there are also major adverse economic effects due to the growing labor force, which will subsequently lead to population growth. Demand for public services will increase, quality of life will decrease, and housing will be a growing

[52] Fox, 2010

concern. Similarly with California, infrastructure damage, maintenance costs, and decreasing property value are also significant concerns.[53]

Pennsylvania has also had its fair share of fracking regulation controversies, especially regarding a 2012 provision, Act 13. The original provision takes away the zoning rights of local municipalities and allows drilling and fracking activities to take place in essentially all zones in the state, including residential zones. Act 13 also contains something that has been labeled a "doctor gag rule" because under this provision, medical professionals are allowed to know what chemical formulas are used in fracking, but they cannot tell anyone else, even other doctors, what the formulas are. Back in December 2014, the Commonwealth Court sided with local governments about the how the restriction of zoning rights is unconstitutional, but as of March 2014, it appears as though much of Act 13 will remain in effect. The Court named four key issues with the provision: the questionable legality of the "doctor gag rule", whether private companies can use the state's domain power to take over private property for fracking activities, the possibility that Act 13 was designed specifically for the oil and gas industry, and which zoning sections remain under the jurisdiction of Act 13.[54]

Germany

The U.S. is not alone in its endeavor to enhance and increase oil and natural gas production—Germany is another world leader in using fracking to extract natural resources from shale rock formations. Like the U.S., about 70% of Germany's energy supply, including renewable energy, is imported. The country itself only produces 25% of the energy resources needed to sustain demand. After the accident at Fukushima I

[53] "Economic Impact," 2014
[54] Cusick, 2014

Nuclear Power Plant caused by a tsunami in 2011, the German government began to plan an energy transition process because of the observed need for more secure energy resources, which included a planned shutdown of all German nuclear power plants by the year 2022. The implication of this shift is replacing 22% of electric energy output with another energy resource, but only 12% of Germany's natural gas is produced domestically due to the continual decrease in conventional reservoirs. As a result there is a need for a mechanism to produce more domestic natural gas and oil, thus the attractiveness of fracking.[55] There are two states in particular of interest because of their shale oil and gas abundance: North Rhine-Westphalia and Lower Saxony. However, as with in the U.S., there is much controversy over fracking and its potential harmful effects. Even though the technique has been used in Germany since the 1950's, it is still a relatively new concept because the targeted shale formations are at shallow depths and there is a greater volume of fractures than there are in conventional gas reservoirs.

As of fall 2013, the German government is still making decisions about whether or not to permit fracking and support shale oil and gas production and what conditions should exist if the decision is approved. A collaborative and comprehensive study by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, and the Federal Environmental Agency was released in 2012 analyzing the environmental impacts of shale oil and gas production processes. Experts of the study recommend strong administrative intervention and scientific overseeing, as well as an in-depth public discussion of the findings to promote transparency of the matter. In December 2012, a panel of experts used this study to discuss and deliberate the potential implementation of

[55] Vetter, 2013

legislation regarding fracking. The bill proposes a required evaluation of the environmental impact of the exploration and production involved with using fracking mechanisms to extract natural gas, crude oil, and geothermal energy. It also requires complete transparency about what happens to the wastewater and flowback and makes it illegal to frack in special water protection areas. After much opposition from citizens and the general public, the bill was not introduced in 2013's elections, thus fracking remains unknown territory in Germany.[56] The decision not to permit fracking in Germany was also based on several risk assessment studies conducted by various companies and agencies. Until environmental issues are resolved, mainly the concern of water contamination, there is an indefinite moratorium on exploring unconventional oil and gas sources.[57]

The current crisis in Crimea may influence Germany to change its mind regarding fracking policies. The country currently imports 35% of its natural gas resources from Russia, but the escalating tensions between Russia and Ukraine are causing German officials to consider the development of new energy policies, specifically of the reintroduction of fracking. Though it has optimistic goals to achieve 80% of its energy from renewable sources by 2050, Germany may have to temporarily abandon those goals and lift the ban on fracking in order to eliminate its dependency on Russian gas.[58]

[56] Vetter, 2013
[57] Nicola, 2013
[58] Richter, 2014

Chapter 5: Legislation & Regulation

Federal Regulation

Clean Air Act

In the United States, the first piece of legislation regarding air pollution passed was the Air Pollution Control Act of 1955. Through a program with the U.S. Public Health Service, scientists researched techniques on how to monitor and control the ever-increasing air pollution problem. The original Clean Air Act was passed in 1963 with the main goal being pollution control. The study of air pollution and harmful emissions expanded with the passing of the Air Quality Act of 1967. A new Clean Air Act passed in 1970, which shifted the federal government's role in pollution control because it granted the authorization of state and federal regulation to limit emissions from industrial and mobile sources. It also authorized the EPA to establish the National Ambient Air Quality Standards aimed to protect the environment, public health, and safety. The Act has been amended twice, once in 1977 and most importantly in 1990. The amendments of 1990 authorized programs for acid deposit control and control of the hundreds of toxic pollutants. Furthermore, a permit program requirement was established, authority was expanded, and a program was set up to eliminate the use of chemicals that deplete the ozone layer.[59]

With regards to fracking, the explicit exclusion of hydrogen sulfide from the Clean Air Act list of harmful substances emitted by oil and gas production has raised many concerns. Hydrogen sulfide is often released unintentionally by oil producing sites, but its effects are a serious threat to human health. These accidental releases occur at sites that

[59] "History of the Clean Air Act," 2013

produce “sour” oil, which contains a sulfur content of over 2%, rather than of “sweet” oil. Because hydrogen sulfide is heavier than air, it is concentrated lower and in closer proximity to humans and wildlife. Exposure to low levels of hydrogen sulfide typically results in headaches, skin rashes, respiratory agitation and tissue damage, confusion, and memory loss.[60]

National Environmental Policy Act of 1969

The National Environmental Policy Act of 1969 (NEPA) was established to provide a general framework to protect the nation’s environment and to ensure that federal agencies take into account how their actions and decisions affect the environment. In Section 101 (b), the Act states "it is the continuing responsibility of the federal government to use all practicable means…to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may…attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable…consequences.”[61] Agencies are required to conduct an initial environmental assessment (EA) and if significant impacts are found, it has to conduct an environmental impact statement (EIS), which provides the public an opportunity to comment and consider the complete spectrum of the impact. The Energy Policy Act of 2005 excluded oil and gas related activities from EAs and EISs, and instead subjected them to be analyzed by the Interior and Agricultural Departments’ processes, which are much less rigorous. This “rebuttal presumption” has minimized the public’s opportunity to be

[60] Kosnik, 2007, 12-15
[61] “National Environmental Policy Act,” Sec. 101 (b)

involved in oil and gas related activities and allows federal agencies to authorize activities without the consent of local landowners.[62]

Clean Water Act of 1972

The Clean Water Act of 1972 (CWA) regulates the release of pollutants into U.S. bodies of waters and sets quality standards for surface waters. Through this Act, the EPA has created pollution control programs to set wastewater standards for different industries. The CWA also made it illegal for a person to discharge a pollutant from a point source into passable waters without obtaining a permit first. Though the EPA pushed to pass storm water regulations at drilling sites, the 2005 Energy Policy Act amended the CWA to exempt sediment from being considered a pollutant, an exemption that applies to oil and gas field construction operations. The EPA concession is inconsistent with past regulations by other agencies that have required sediment discharge permits in light of storm water runoff. Thus, with regards to fracking, it has proven difficult to regulate and categorize wastewater runoff.[63]

Safe Water Drinking Act 1974

Congress passed the Safe Water Drinking Act (SWDA) in 1974 in order to protect public drinking water and its sources including rivers, lakes, reservoirs, springs, and wells that serve more than 25 people. Furthermore, the SWDA sanctions the EPA to create national drinking water health-based standards to protect water from natural and man-made pollutants. Threats to clean water include animal wastes, pesticides, human wastes, and deep-injected underground chemicals, among other things. The law was amended in

[62] Kosnik, 2007, 15-16
[63] Kosnik, 2007, 19

1996 to ensure that the sources supplying tap water were safe and clean as well.[64] The Energy Policy Act of 2005, which thinned out the existing protection laws thereby threatening public health, further amended it. Fracking facilities and operations are entirely exempt from being regulated by the Act, even if diesel fuels are found in underground drinking sources. The fluids used in the fracking process contain a variety of chemicals used to create fractures in the rock formations, many of which are inherently toxic.[65]

In 2004, in response to the concerns of many citizens, the SWDA required the EPA to conduct a study of the impacts of fracking on underground sources of drinking water (USDW). In particular, the study focused on the effects of fracking coalbed methane wells through direct injection of frack fluids, through a natural fracture system, or through the creation of a connection between the formation and a nearby USDW. The study concluded that injecting frack fluids into the wells posed a marginal threat to USDWs and did not require further study.[66] However, in 2011, Congress requested another national study be conducted with a projected 2014 completion date. The study's purpose is to "assess the potential impacts of hydraulic fracturing on drinking water resources…and to identify the driving factors that may affect the severity and frequency of such impacts".[67] This study specifically focuses on fracking shale formations and natural gas. As of April 2014, the study has still not been released for peer review.

[64] "Water: Safe Drinking Act," 2013
[65] Kosnik, 2007, 8-10
[66] "Chapter 7," 2004
[67] "Executive Summary," 2012, 1

Resource Conservation and Recovery Act of 1976

The Resource Conservation and Recovery Act (RCRA) of 1976 requires that federal agencies and organizations evaluate the effects of debris, hazardous wastes, and waste clean-up projects on air and water-quality. The Act also requires that agencies take appropriate actions to prevent degradation of the local environment and gives the EPA the right to control hazardous waste that comes from facilities. It allows them to create a managing system for the hazardous wastes that come from transportation, treatment, storage, and disposal.[68] This portion of the Act is in Subchapter III (Subtitle C), which refers to this management program as "cradle-to-grave". A "cradle-to-grave" analysis assesses environmental impacts of an act or production process from the beginning until the end and helps avoid viewing environmental concerns in too broadly of a manner. According to the Act, hazardous wastes include solid wastes that can contribute to illness or death or pose any kind of irreversible risk to the environment or human health. In 1978, the EPA wanted wastes from oil fields to be considered a hazardous waste, but Congress's response was to create a separate Solid Waste Act (SWA) that exempted oil field wastes until they were proven to a threat to human health and/or the environment.

Ten years later, the EPA decided to accept the exemption, an action known as the 1988 Regulatory Determination. In 1993, the EPA provided further explanation to determine if an oil field waste was exempt from the RCRA regulation. The exemption allows deadly chemicals such as carcinogens to contaminate air and water sources that serve the public and the environment. The EPA has not generated estimates on the amount of waste produced by oil and gas wells since 1985, thus, if the amount was

[68] "Resource Conservation & Recovery Act"

measured in the present day, there would be an exponential amount of produced water and waste.[69] According to the Division of Oil, Gas, and Geothermal Resources (DOGGR), in 2012, California produced 3,083,038,501 barrels of wastewater, a number 16 times greater than the amount of oil that was produced.[70]

The Energy Policy Act of 2005

The Energy Policy Act of 2005 exempts fracking and other forms of gas and oil drilling from the SWDA and the CWA, something that is known as the Halliburton Loophole. It became known as such because of former Vice President Cheney's affiliation with Halliburton Corporation, a Texan company that initiated the fracking process. Under this Act, the EPA can no longer regulate or monitor injection of chemicals underground during the fracking process and fracking is completely exempt from regulation by the Underground Injection Control Program (UICP), which was established in 1974 under the SWDA. Though there has been a widely negative reaction to the exemption, no federal laws have passed to regulate fracking more closely.[71]

California Legislation

Senate Bill 4

Senate Bill 4 (SB 4), sponsored by Senator Fran Pavley (D-Agoura Hills), was introduced on December 3rd, 2012 and was approved by Governor Brown on September 20th, 2013. It was the only bill regarding fracking and acidization that passed through California's 2013 legislation and was put into effect on January 1st, 2014. SB 4 allows fracking to continue and take place as long as well permits are obtained and under the

[69] Kosnik, 2007, 12
[70] Kustic, 2013, 3
[71] Hines, 2012

condition that DOGGR publicizes a regulation program by January 2015. Under DOGGR, well stimulation is allowed to proceed as long as the well owner receives a permit and provides DOGGR with a complete well history. Furthermore, DOGGR must conduct an EIR in accordance with the California Environmental Quality Act (CEQA). SB 4 also outlines several actions that must be completed before 2015. Before the first of the year, the Natural Resources Agency must conduct and complete an independent scientific study regarding the risks and hazards that well stimulation poses to the public and the environment. DOGGR is also required to work closely with other state agencies to create and implement regulation for well stimulation treatments. By July 1st 2014, the State Water Resources Control Board must develop criteria for monitoring groundwater affected by well stimulation. Furthermore, DOGGR must develop a website by 2016 that requires owners and operators to publicize well stimulation activities.[72] SB 4 is designed to require the collaboration of DOGGR with other state agencies in overseeing fracking and acidization activities, in order to provide more effective regulation.

Along with outlining responsibilities for DOGGR and state agencies, SB 4 also outlines specific guidelines for well owners and operators to abide by. Before performing any well stimulation activities, owners/operators must apply for a permit with a supervisor or director at DOGGR. The permit must include the well number, when stimulation will take place, a water management plan, a list of chemicals used, the size and direction of the fractures, a groundwater monitoring plan, and an estimate of the expected amount of produced waste. Before applying for a permit, the owner/operator must also assist DOGGR in completing an EIR report and notify neighbors located

[72] "Governor Jerry Brown," 2013

around the property of the tentative permit, something known as a well stimulation notice. Once a permit is a received and well stimulation takes place, owners/operators must sample water sources that may have been contaminated and upload a concluding report to DOGGR's website.[73] Prior to implementing permanent regulations in 2015, there is an interim well stimulation regulation period that is good for the first six months of 2014. These permits must be renewed in the summer of 2014 if well stimulation is going to continue. As of January 2014, 249 permits/notices have been submitted to DOGGR—99% are in Kern County, submitted by four different operators in seven separate fields. Of these 249 permits, 14% were for acidization and the rest for fracking.[74]

After reviewing the legislation and the submitted well permits, the Senate Committees on Natural Resources and Water and Environmental Quality have raised some concerns regarding SB 4. The approved well stimulation certification notices on DOGGR's website all claim to be exempt from groundwater monitoring because of the "lack of 'protected waters' surrounding the well" (6).[75] There is no clear description of what these "protected water" zones are and why they are exempt from regulations. Another concern is the incompleteness of the notices, including incomplete reporting of chemicals used and their accurate concentrations, inaccurate reporting of well location, inconsistency of notifying neighbors, and vague disclosures. Overall, the reports on DOGGR's website are sloppy, inconsistent, and confusing. The bill also makes no reference to offshore fracking activities, even though the bill allegedly applies to offshore and onshore well stimulation activities in California state waters. The issue of trade

[73] "Governor Jerry Brown," 2013
[74] "Senate Bill 4 Implementation Plan," 2013
[75] "Senate Bill 4 Implementation Plan," 2013

secrets, which are techniques or devices used by oil owners/operators in fracking, also arises in the legislation. Although the bill does not allow for trade secret protection, operators are only required to report trade secrets to public agencies if a spill occurs or to a physician who would be required to treat an individual in a medical emergency.[76] An important recent rising concern is about the regulation of acid use in well stimulation. The bill requires that DOGGR establish an acid threshold value based on volume, but regulations have disregarded these instructions and have instead reported an arbitrary acid concentration of 7%, causing a loophole. Operators could potentially use thousands of gallons of acid in treatments and avoid regulation.[77] The bill has caused controversy because anti-fracking activists do not believe fracking should be allowed to continue until the study is a complete and the exact impacts are released.

Senate Bill 1132

On February 20, 2014, Californian Senators Holly Mitchell (D-Los Angeles) and Mark Leno (D-San Francisco) introduce Senate Bill 1132 (SB 1132), a bill that would impose an indefinite moratorium on fracking and acidization in the state. The goal of the bill is to protect the air and water from pollution, which in turn would decrease fracking's negative impact on public health. The bill was introduced at a critical time: California is facing its most severe drought in fifty years, yet Governor Jerry Brown has still demonstrated fracking support. All fracking would come to a halt until a "comprehensive, independent and multi-agency review exploring the economic, environmental and public health impacts is complete."[78] The bill would require the identification of all onshore and

[76] Vekshin, 2013
[77] "Senate Bill 4 Implementation Plan," 2013
[78] Bacher, 2014

offshore oil and gas drilling activities; evaluating the possible effects to ground and surface water; evaluating the risks of produced water and other fracking byproducts; considering atmospheric impacts on California's Cap and Trade laws; and lastly, examining the effects of fracking on low income communities.[79]

California does not currently have any legislation that specifically regulates fracking or acidization. This lack of regulation is exemplified by the continued use of 29 chemicals that are known to be harmful to human health, yet are still commonly used in fracking. State environmental groups such as the Center for Biological Diversity (CBD), Sierra Club, Clean Water Action, Natural Resources Defense Council, and Food and Water Watch heavily support the bill for. Not surprisingly, the Western States Petroleum Association (WSPA) staunchly opposes the new bill, arguing that California already adheres to strict regulation after the passing of SB 4. The WSPA, along with other oil industry companies, is one of the most influential lobbyists regarding environmental processes and has spent over $20 million dollars on lobbying against fracking bills since 2009.[80]

Senate Bill 1281

Senator Pavley introduced another bill on February 21, 2014, which requires a reduction in the use of freshwater in oil and drilling operations by the year 2019. DOGGR, the State Water Resources Control Board, and the State Department would determine the baseline of volume reduction. The bill would also require that well and facility owners report to DOGGR regarding the volume, source, and purpose of all the water used in the operation, whether it is fresh, recycled, or treated. This information

[79] "Senate Bill 1132," 2014
[80] Bacher, 2014

would be available to the public.[81] The self-reporting will help regulators know where water for fracking is coming from and how that subsequently affects the environment and residents who reside in those areas. For example, if operators are using freshwater from local drinking sources, regulators will be able to take direct action.

Senate Bill 1319

On the same day that SB 1281 was introduced, Senator Pavley introduced Senate Bill 1319 (SB 1319), a bill that would amend the existing Lempert-Keene-Seastrand Oil Spill Prevention and Response Act. In addition to changing how facilities obtain certificates of financial responsibility, the bill would also monitor and analyze how oil is transported into and within California and "the properties of the oil to identify necessary changes in oil spill response and preparedness programs."[82] Oil spill prevention and response is currently an important topic because of the increasing amount of crude oil that is being transported throughout the state, especially in the Bay Area.

Assembly Bill 2420

Assemblymember Adrin Nazarian (D-Sherman Oaks) introduced Assembly Bill 2420 (AB 2420) on February 21, 2014, a bill that would "authorize a city or county to adopt and enforce a local ordinance prohibiting well stimulation treatments."[83] If this bill passed, it would be a huge step in the ability of local governments and municipalities to completely ban fracking, especially those that are staunchly opposed. Many local communities have already taken fracking bans and regulations into their own hands. Local actions to pass anti-fracking measures have taken place in Arroyo Grande,

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[82] Pavley, 2014
[83] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2420

Berkeley, Carson, Culver City, Fairfax, Marin County, San Luis Obispo, Santa Cruz County, Los Angeles, and the San Francisco Board of Supervisors.[84] In addition to calling for temporary bans on fracking until investigations and reports are completed regarding health and environmental effects, local communities want more state and agency regulation. Though many proponents of fracking have argued that local governments do not have the authority to ban fracking, the Center for Biological Diversity released a review arguing otherwise. The California Public Resources Code explicitly states that local authorities have the right to "enact and enforce laws and regulations regulating the conduct and location of oil production activities, including…zoning…public safety, nuisance…[and] noise…",[85] thus confirming that local governments constitutionally hold the right to ban oil and gas developments in their jurisdiction.[86]

California Regulation

The Division of Oil, Gas, and Geothermic Resources

The California Department of Conservation is the main regulator of the state's fracking through the Division of Oil, Gas, and Geothermic Resources (DOGGR). DOGGR's various supervision responsibilities include drilling, operation, maintenance, and abandonment of California's 88,500 active onshore and offshore oil and natural gas wells. DOGGR is in charge of granting well permits, inspecting well sites and facilities, overseeing plugging and abandonment contracts, and subsidence monitoring. The agency has been widely criticized and scrutinized due to its suspected close ties with the oil and

[84] "Local Resolutions"
[85] Cal. Pub. Res. Code 3690
[86] Kretzmann & Siegel

gas industry.[87] DOGGR is in charge of overseeing the implementation of SB 4, which includes the development of an EIR by July 1, 2015, requested by CEQA. The goals of the EIR are to "ensure DOGGR's compliance with a requirement of SB 4; identify, evaluate, and disclose the potential environmental impacts of well stimulation treatments of both conventional and non-conventional oil and gas resources within the State; further the Legislature's efforts to ensure that well stimulation practices are conducted in a manner that assures environmental protection, public safety, data collection, and reporting, interagency coordination, regulatory oversight and monitoring, and public disclosure; and, allow for the safe recovery and production of the State's oil and gas resources".[88] CEQA has also required that DOGGR develop a scoping process and hold scoping meetings in order to hear and address the concerns of the public and the agencies. CEQA developed out of President Nixon's National Environmental Policy Act (NEPA) with the primary objective of providing the general public and the government information about how state projects would affect the environment. The act also outlines every individual's responsibility to respect the environment and requires that state agencies closely regulate both private and public corporations.[89]

The Bureau of Land Management

The Bureau of Land Management (BLM) oversees and manages California's public land and potentially holds the authority to regulate fracking and enforce standards in the near future. According to the agency's website, the BLM manages 15.2 million acres of surface land and 47 million acres of mineral estate in California. Much of the land it

[87] "California Regulations," 2013
[88] "Notice of Preparation," 2013, 3
[89] O'Reilly, Section I

manages and leases is located in the San Joaquin Valley, the state's oil producing hub.[90] The BLM found itself in a legal situation in 2013 when it was ruled that it had violated NEPA by selling oil leases in Monterey County without conducting a complete environmental assessment. The "assessment" used only one scenario and failed to consider the dual effects on the environment by fracking and horizontal drilling, thus the BLM erroneously concluded that fracking had no significant environmental impact.[91] The agency was ordered under the law to conduct another study to examine all fracking technologies and record the adverse environmental effects. The study is expected to be completed in late spring of 2014.[92]

The Environmental Protection Agency

Another agency heavily involved in regulating California fracking is the U.S. Environmental Protection Agency (EPA), an agency founded over four decades ago by President Nixon with the main objective being the protection of the nation's environment and its residents' health. The EPA's involvement in fracking regulation includes conducting informative studies, developing industry recommendations/regulations, and ensuring that those involved in the fracking industry comply with the regulations. As discussed previously, the EPA is currently in the process of compiling a report that investigates the impacts of fracking on drinking water sources, a request made by Congress under the SWDA. The agency has also recently passed a regulation requiring that offshore fracking facilities be completely transparent about the specific chemicals disposed of into the ocean. The problem with this new regulation, that recently became

[90] "Oil and Gas," 2014
[91] "Court Holds that BLM Violated NEPA," 2013
[92] "Hollister Field Office," 2014, 1-2

effective in March 2014, is that it only applies to new drilling sites, not those already existing.[93] Thus, there is nothing stopping the dozens of platforms in the Santa Barbara Channel from dumping thousands of gallons of toxic waste into the surrounding waters. However, the regulation will provide important information regarding the chemical composition of fracking wastewater and scientists will thus be able to have a greater understanding of how these chemicals affect marine life and human health.

Another recent development has shown that the EPA is not always consistent in enforcing regulations. In February 2014, the Center for Biological Diversity (CBD) issued a legal petition asking the EPA to regulate the disposal of offshore fracking chemicals into California's ocean. Offshore fracking platforms in the Santa Barbara Channel dump most, if not all, of their wastewater into the ocean, but are permitted to do so by a federal permit. The CBD petitions that the EPA modify this federal permit and develop offshore fracking pollution guidelines for the entire nation.[94] The agency is currently in the process of developing the requested guidelines, but the oil industry still continues to dump toxic chemicals into the waters, severely threatening the aquatic environment.

The South Coast Air Quality Management District

The South Coast Air Quality Management District (SCAQMD) controls and regulates air pollution in Orange County, Los Angeles County, Riverside County, and San Bernardino County. The SCAQMD was the first California agency to regulate fracking when it introduced Rule 1148.2 in April 2013, which requires that the owners and operators of oil and gas wells in the agency's jurisdiction inform the ruling Executive

[93] Chand & Dearen, 2014
[94] Sakashita, 2014

Officer of all ongoing well activities including drilling, completion, reworking, and stimulation involved with fracking. Operators must report electronically to the SCAQMD website at least 24 hours prior to commencing activities. A map of all well sites is available online. In addition to well activities, the rule requires the reporting of chemicals and emissions.[95] The Rule became effective in June 2013 and will stay effective for two years. There are several pros and cons of self-reporting mechanisms. Knowing exactly where fracking is taking place and what techniques are being used will greatly help regulators impose new rules and recommendations, but on the other hand, self-reporting may not always be accurate.

[95] Wallerstein, 2013

Chapter 6: The Impacts of Fracking

Health

Many recent studies have explored the already existing and potential impacts of fracking on human and animal health. The main source of concern stems from the 750 known chemicals that are used in the process, many of which are toxic to humans and have remained concealed from the public due to "trade secret" claims made by operators. Individuals living in close proximity to fracking sites are exposed to health risks through contaminated water and polluted air. Local drinking water sources become contaminated with methane, arsenic, and radium due to leaks and other accidental drilling procedures. Ground and surface water become polluted because of produced water, an especially concerning issue considering the majority of California fracking sites are located in close proximity to farmland. The 2010 documentary *Gasland* publicized the effect of fracking water pollution in Pennsylvania by filming a scene in which a family's tap water bursts into flames when lighted with a match. Because the water is undrinkable, residents must find outside water supplies without compensation or aid from fracking operators. Consuming polluted water containing radioactive materials can lead to an increase risk of various serious health effects, including respiratory diseases and cancer. A 2010 study conducted by the University of Missouri, the U.S. Geological Survey, and the Columbia Environmental Research Center, found that 12 fracking chemicals found in contaminated water sources disrupt the activities of male and female sex hormones. Chemicals such as these are known as endocrine-disrupting chemicals (EDCs), and have been identified as possible causes of breast cancer. Though the results of the study are not entirely

conclusive, they do highlight the potential dangers of fracking on the human endocrine system.[96]

California residents, particularly in the Los Angeles area, have complained and shown signs of adverse health effects stemming from air pollution such as headaches, nausea, nosebleeds, and respiratory illnesses. When EPA officials came to visit a fracking site in West Adams near University Park, they immediately fell ill, leading to the halt of all operations until a thorough investigation takes place. Once the operation shut down, residents' symptoms disappeared.[97] Fracking communities have higher than normal levels of the following air emissions: ozone, methane, formaldehyde, radon, nitrogen oxides, silica sand, hydrogen sulfide, and particulate matter. Formaldehyde is a classified human carcinogen, as well as having known short-term health effects such as eye and skin irritation.[98] According to the EPA, radon, a radioactive and odorless gas, is the main cause of lung cancer in nonsmokers and increases the risk of lung cancer in smokers.[99] Los Angeles has some of the highest levels of nitrogen dioxide, a gaseous air pollutant that damages lung function and increases susceptibility to respiratory infections.[100] Hydrogen sulfide is highly flammable and explosive, thus presenting a serious danger when used in such close proximity to communities. It can also cause unconsciousness. Ozone and methane greatly contribute to air pollution and are further discussed below in the section regarding air quality. The health effects of silica sand and particulate matter are also discussed in greater detail under the section about safety. severe headaches, and

[96] Vandenberg et al., (2012)
[97] Sahagun, 2013
[98] "Formaldehyde and Cancer Risk," 2011
[99] "Radon," 2013
[100] "Radon," 2013

poor attention span.[101] Furthermore, studies have also shown a link between fracking location and evident low birth weights, birth defects, respiratory issues, and fertility issues in women.[102]

Along with physical health impacts, fracking also has detrimental effects on community and social health. The rise in traffic and vehicles leads to an increase in accidents and injuries, as well as an increase in psychological stress levels. Fracking sites also produce elevated noise pollution, which disrupts sleep, increases aggression, and has been linked to cognitive impairment. Fracking has also changed demographics and social norms of communities, such as increased levels of drug and alcohol use. Because fracking causes a variety of health effects, community residents experience higher health care costs, adding another associated social stressor and financial burden.[103] The Office of Environmental Health Hazard Assessment developed a report to study the cumulative impacts of pollution sources on affected communities. Cumulative impacts are defined as "exposures, public health or environmental effects from the combined emissions and discharges…including environmental pollution from all sources" and can either be accidental or routine.[104] Instead of analyzing the single effects of fracking, such as air pollution or water pollution, it is more important to study the overall combined effects of the pollutions in order grasp a better understanding of the degree to which communities suffer. It is also important to consider factors outside of fracking that adversely affect populations, such as low socio-economic status and location. For example, there is low-income community housing located in the AllenCo Energy's West Adams drilling site.

[101] "Hydrogen Sulfide"
[102] "Toxic Secrets," 2013, 18
[103] "Toxic Secrets," 2013, 20-21
[104] Adams & Denton, 2010, vii

Not only do these residents have to deal with health effects set forth by fracking, but they also have limited health care access and lack of open space due to the operating facilities.

Safety

Fracking has also led to various safety concerns: the dangers and risks of transporting crude oil by trains, transporting crude oil by pipelines, industrial accidents, and the safety of industry workers. Transporting oil by rail within the nation is relatively recent development that arose because of the discoveries of vast amount of crude oil in North Dakota and Montana and in the tar sands of Canada. In 2013, the Association of American Railroads reported 400,000 transports of oil by rail across the U.S., a 4,000% increase from the amount of rail transports recorded six years prior.[105] The figure below illustrates the recent rise in California oil imports, particularly from North Dakota's Baaken region, just within the last year.

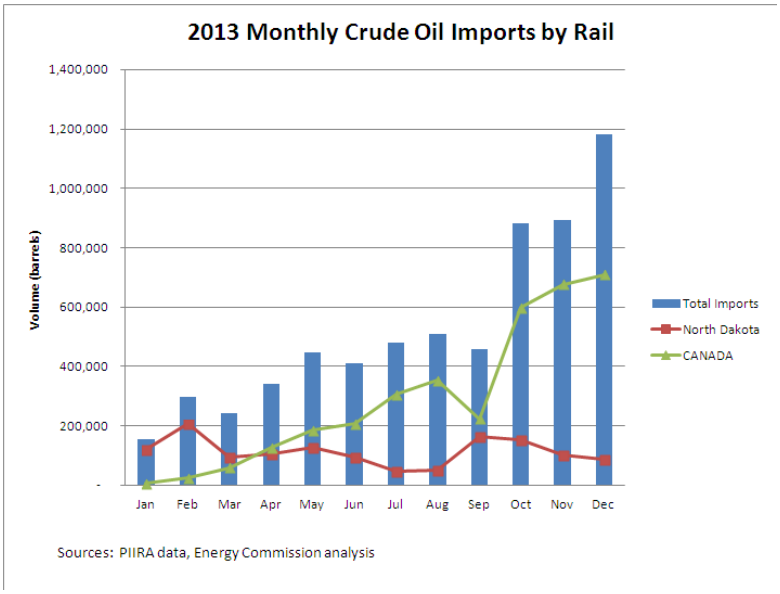

Figure 4. The amount of crude oil imported to California in 2013 (Source: CA Energy Almanac).[106]

[105] "Safe Rail Transport," 2014
[106] "Crude Imports by Rail," 2014

Due to recent explosions and derailments, there are rising concerns about the dangers of oil transport by railroad. There has been an astonishing number of oil-rail incidents in the last 6 months of 2013 and the beginning months of 2014. The most astonishing accident occurred in July 2013 in the Canadian town, Lac-Mégantic, when a 74-car freight train carrying crude oil derailed on its journey from North Dakota. Forty-seven people were killed, dozens of buildings were destroyed, and the local river became contaminated with 26,000 gallons of crude oil. In October, 13 cars derailed on a trip from Canada; in November, 90 cars derailed from North Dakota; in December, two trains collided, causing a 34-car derailment; in January, five oil carrying cars exploded coming from New Brunswick; and lastly, in February 2014, a train from Canada derailed and spilled over 3,000 gallons of crude oil.[107] These series of incidents has left many open-ended questions about the future of oil transportation by rail and opened up discussion about the need for tighter restrictions and regulations. In addition, there is speculation about the increased risk of explosion and ignition of oil from the Baaken region. Figure 5 below provides illustrates the main and shortline railroads in California.

[107] "Safe Rail Transport," 2014

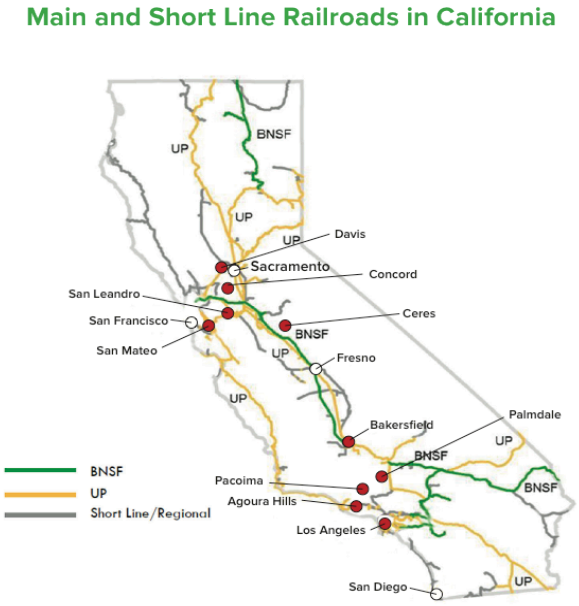

Figure 5. The main and shortline railroads in California's network (Source: Safe Rail Transport).

Another mode of transporting oil is by pipeline, which has instigated a controversial debate among the entire nation because of the proposed Keystone XL Pipeline Project, which will expand already existing pipeline by 1,700 miles. The concerns arise from two sources: the detrimental health and environmental effects, which will not be discussed in detail in this paper, and the worry that if the project is killed, oil by rail will continue to increase exponentially. Thus the question becomes, which is safer—transportation of crude oil by rail or by pipeline? A study conducted in January 2014 by the U.S. Department of State Bureau of Oceans and International Environmental and Scientific Affairs examines various hypothetical situations if the project does not proceed. In the first scenario, Baaken crude oil would be transported by rail from Canada to Oklahoma, temporarily stored, and then further transported through existing pipelines, where it would eventually reach Oklahoma interstate pipelines. This would require

constructing 10 new loading terminals and building 14 new trains in order to transport the same amount of oil that the proposed pipeline would have been able to. The other two scenarios predict similar necessary actions in order to transport oil to different areas in the nation.[108] Proposed alternatives to the pipeline present additional environmental and health impacts that may impose greater threats than the original project plan because of the required increases in transport by rail. The steep increases in the severity and number of oil spills and explosions due to oil transport by rail provide evidence to the claims that pipelines may be a safer decision.

Another area of safety concern in fracking stems from the industrial processes involved in the drilling and refining processes and the dangers industry workers face on the job. The Occupational Safety and Health Administration (OSHA) in collaboration with the National Institute for Occupational Safety and Health (NIOSH) have issued a hazard alert regarding the exposure dangers of crystalline silica (silica) to fracking workers. Silica, a mineral found in Earth's crust, becomes respirable during fracking because its components are small enough to become entrapped in the gas-exchange portion of the lungs. Workers become exposed to the silica sand when transporting and moving it through seven different steps in the fracking process. The report states that high levels of silica exposure can cause silicosis, a lung disease that causes inflammation, scarring, reduced oxygen consumption abilities of the lung, and may eventually lead to the development of lung cancer. In addition to silica exposure, the alert lists various other worker dangers associated with fracking: exposure to exhaust gases, high noise levels,

[108] Walker, 2014, 28-29

temperature extremes, physical overexertion, and exhaustion.[109] Industry workers are also at a greater risk of being exposed to particulate matter, which is a mixture of small particles, such as organic chemicals, metals and dust particles, and liquids, such as acids. Like silica sand, smaller particles cause more throat and lung damage.[110]

Workers also have to work with hydrofluoric acid (HF), which is known to be an extremely dangerous chemical used in industrial production. HF is used in the acid fracking process, where it is injected in high volumes and at high pressure into oil wells in order to dissolve deep rock and allow oil to flow up to the surface. The acidizing process is widely unregulated, thus California oil companies have been using acidizing with HF concentrations estimated to be as high as 30%. HF can severely burn eyes and skin and can over time damage the lungs as well. Depending on the concentration, HF exposure can lead to death. Its ability to corrode almost anything has earned it the title as the most dangerous hazardous material according to the U.S. Centers for Disease Control and the National Fire Protection Association system. HF is also widely used in the refining process, adding another element of danger to workers in California refineries.[111]

Farming, Agriculture, & Food

California is the nation's top agriculture producer because of its temperate climate and abundance of fruitful land resources. The recent predictions regarding the Monterey Shale's suspected volume of shale oil and gas in South and Central California have resulted in an increase in fracking operation activities on agricultural land. These regions produce the majority of the state's agricultural output. Fracking processes cause soil and

[109] "Worker Exposure," 2012
[110] "Particulate Matter," 2013
[111] Collier, 2013, 3-6

water contamination, which in turn affects the health of livestock and agriculture. In one highly publicized incident, farmer Fred Starrh sued Aera Energy Inc. for leaking pollutants and wastewater that contaminated his land, causing billions of dollars in damage. A 2012 study looking into the impacts of fracking on human and animals' health concluded that livestock in particular are extremely sensitive to released pollutants. The researchers interviewed animals' owners and their veterinarians in six states, as well as conducting water, soil, and air quality tests. Two-thirds of the cases involved high-volume fracking wells, while the rest involved conventional drilling in order to serve as a control. In two out of the six cases, livestock were directly exposed to fracking fluid, which caused 17 cows to die in one hour in one instance and reproductive issues in goats in the other. The rest of the case studies involved indirect exposure to fracking fluids through contaminated land and water. The most common finding across all studies was reproductive issues in cattle, including stillborn calves and survival failure.[112]

Air emissions produced by fracking, such as methane and ozone, also pose a threat to agriculture because they have been found to inhibit photosynthesis and root production, thus causing noticeable decreases in annual crop yields and causing severe economic loss. Water is also another area of concern for farming because fracking's high demand for water and the state's current drought has caused inevitable competition for water sources. This competition also proves to be harmful for local residents because water prices are driven up. Lastly, fracking has created an issue between landowners and mineral owners, because under the law, they are regarded as two distinct and separate "split estates". In this scenario, even though one entity may own the surface land, another

[112] Bamberger & Oswald, 2012, 53-61

entity may own the oil and gas below the surface. This is how private energy companies (or public agencies) are able to set up drilling operations on private or public land and property owners cannot prevent them from doing so. Thus farmers have no control over who fracks on their land and the inevitable contamination that it causes.[113]

Induced Seismicity

California has a substantial history with seismic activity, due to its geographical location in an area containing over 15,000 faults, the most infamous being the San Andreas Fault. There have been various proponents who believe that fracking causes induced seismicity, which refers to an earthquake caused by human activities that would not have occurred in the absence of the said activity. Injecting high-pressure fluid into shale rock formations in order to create networks of open fractures to extract hydrocarbons inevitably causes micro-earthquakes, typically with magnitudes less than M1.0. As fracking locations have increased, so have the number and frequency of earthquakes felt by surrounding residents; however, the magnitudes of these earthquakes have not been strong enough to cause structural or severe damage. Several studies in the United Kingdom, as well as in the Marcellus Shale of the Appalachian Basin in Pennsylvania, have shown a direct correlation between fracking and seismic activity. Most recorded earthquakes have had a magnitude of less than M2.3 and are not far from normal and expected seismic patterns. However, unusual patterns of earthquakes were recorded in British Columbia in 2009, near the Horn River Basin, with magnitudes greater than M3.0 and reaching a maximum of M3.6. An investigation concluded that the

[113] "Impacts: Food," 2013

fluid injection during hydraulic fracturing near pre-existing faults, conducted by the BC Oil and Gas Commission, caused these series of earthquakes.[114]

In March 2014, Earthworks, the CBD, and Clean Water Action released a collaborative report about fracking and earthquake risk in California. Injecting fracking wastewater into wells is the part of the process that subsequently results in increased seismic activity. California produces billions of gallons of wastewater annually—significantly more than the amount of oil it produces—thus it all must be managed somehow. The recent rise in fracking activities has also led to the inevitable rise in wastewater. The study found that more than half of the state's 1,553 wastewater injection wells are located within 10 miles of faults that have been active in the last 200 years. The correlation between well proximity to fault lines and earthquakes raises a significant concern. For many years now, scientists have proven that wastewater injection wells can in fact induce earthquakes due to the pressure that builds up in rock formations following the injection. If the pressure is transmitted to nearby faults, an earthquake may occur.[115] Figure 6 below illustrates the locations of wastewater injection wells, as well as active faults and active fracking sites.

[114] Ellsworth, 2013
[115] Arbelaez et al., 2014, 7-9

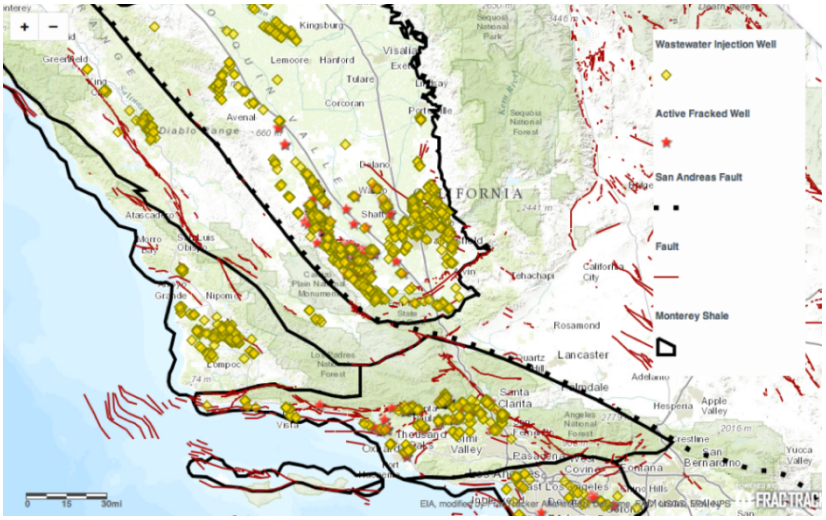

Figure 6. A map of Southern California's fault lines and wastewater injection wells (SOURCE: CAFrackFacts).[116]

The report also proves that in regions where fracking has increased, so has earthquake activity as demonstrated by the parallel booms in Oklahoma, Texas, Colorado, New Mexico, Arkansas, Ohio, and West Virginia. Resulting earthquakes from fracking also pose dangers such as leaks and spills caused by damage to well casings that could in turn lead to groundwater contamination. California's earthquake frequency also poses a huge threat to residents and the extensive infrastructure. Heavily populated areas in Los Angeles and Bakersfield are in close proximity to the majority of wastewater injection wells and to recently active faults. Other areas facing a high degree of risk are Kern and Ventura Counties. Not only do induced earthquakes produce safety costs and concerns, but large economic costs as well.[117] For example, an earthquake of a magnitude of M5.6,

[116] "Where is Fracking Occurring?" 2013
[117] Arbelaez et al., 2014, 15-26

which is a plausible magnitude for a fracking-induced earthquake in California, can cause over $4 billion in damages.[118]

The lack of investigative reports and studies regarding induced seismic activity by wastewater injection wells leaves many unanswered questions that need to be addressed. In addition, California lacks critical information about fault locations and size. The lack of regulation regarding induced seismicity risk, such as DOGGR's laissez-faire approach to seismic monitoring at injection well sites, is also an area of concern. By failing to take action and provide regulation, the state is continuing to put the public at risks associated with safety and health.[119] A recent series of earthquakes in Los Angeles in mid-March has led to the calling for an investigation by city councilmen to look into whether or not fracking was a causing factor. Councilmen Paul Koretz and Mike Bonin have asked city departments to collaborate with DOGGR, the U.S. Geological Survey (USGS), and SCAQMD to explore what role fracking played in inducing the M4.4 earthquake.[120] After experiencing a similar series of events, Ohio placed a temporary ban on fracking operations that were in close proximity to active faults.

The USGS has completed extensive studies investigating the impacts of human activity on earthquake stimulation. For example, in March it issued a press release that concluded that a M5.7 Oklahoman earthquake in 2011 was caused by unintentional human activity, more specifically a human induced earthquake by wastewater injection that occurred the previous day. Though there are no definite concluding remarks about the direct link between fracking and seismic activity, the important observation is that a

[118] "Earthquake," 2014
[119] Arbelaez et al., 2014, 25-27
[120] Reyes, 2014

human-induced earthquake can trigger other even larger earthquakes.[121] Another published study by the Geological Society of America studied the same series of earthquakes in Prague, Oklahoma and concluded that the wastewater injection caused increased fluid pressure, which in turn induced a M5.0 earthquake, which later triggered the M5.7 earthquake.[122] In another instant, Ohio imposed stricter regulations on oil drilling facilities in April due to a probable link between fracking near fault lines and increased earthquake activity. The Ohio Department of Natural Resources is requiring drilling companies "to install seismic monitors if they want to frack within three miles of a known fault line, or where an earthquake has already occurred."[123] If seismic activity greater than M1.0 on the Richter scale is detected, fracking operations must stop. Furthermore, if a study conducted by the state determines that there is a "probable" connection between fracking and earthquakes, drilling at well sites will be terminated, regardless if they are incomplete.[124]

Air Quality, Climate Change, & GHGs

California has long had noticeably worse air quality than other states, most likely due to heavily populated urban and industrial regions. According to a 2013 American Lung Association report, Los Angeles continues to have the worst ozone pollution problem. Bakersfield and Merced were both in first place for the worst annual levels of particle pollution in the nation. The report highlights the greater risk that Californians face with regards to particle pollution because 67% of the nation's most polluted counties

[121] Garcia, 2014
[122] Keranen et al., 2013, 700
[123] Bastasch, 2014
[124] Bastasch, 2014

are in the state.[125] Other recent reports have demonstrated that one-third of the state lives in areas that do not meet U.S. air quality standards.[126] The main culprit of California's unsafe and unhealthy air quality is ozone, also commonly known as smog, and particle pollution. Burning fossil fuels is the main source that releases gases that form ozone when they react with sunlight. Breathing ozone causes serious health impacts such as premature death, immediate breathing problems, cardiovascular problems, and long-term exposure risk. Particle pollution, most commonly found in exhaust smoke, presents another source of health effects. It is a mixture of breathable solid and liquid particles that come in different sizes—the smaller the particles, the more likely they are to enter the human body. Short-term particle pollution exposure diminishes lung function, increases asthma risk, increases infant mortality, increases heart attack risk, and can even be lethal.[127] Fracking has greatly contributed to pollution increases and worsening air quality because of the chemical and mechanical processes involved.

The majority of California's oilfields produce heavy or extra-heavy oil, meaning that it takes more energy to refine it into lighter grade fuels. These energy-intense processes emit significantly high levels of carbon dioxide (CO_2)—levels that may ultimate violate the state's regulations set forth by the Cap and Trade law, Assembly Bill 32. If predictions about how much crude oil is available for extraction from the Monterey Shale is accurate, the amount of CO_2 emitted would well exceed the emissions limit set forth in 2010. CO_2 is the main GHG emitted by humans through electricity, transportation, and industry and is causing climate change and global warming. Fracking

[125] "State of the Air 2013", 6-18
[126] Barboza, 2014
[127] "State of the Air 2013", 32-34

also emits high levels of methane (CH_4), which is the second highest emitted greenhouse gas from human activities after CO_2.[128] A study published in the Proceedings of the National Academy of Sciences (PNAS) found that methane emissions from fracking are higher than estimates by the EPA, by as much as 50%.[129]

Water

Water plays a major role in the fracking process, thus its use in the process has been meticulously studied, recorded, and criticized. According to a report by an information system developed by the California Natural Resources Agency called Ceres, the average California drilling well utilizes 134,000 gallons of water, totaling about 45 million gallons of water used annually. This number will only increase as fracking increases. California's recent state of extreme drought has brought into question the governor's plan to continue to grant drilling permits. According to the report, 98% of wells are in high or extreme water stress regions and 100% of wells are in medium or higher water stress regions. Kern County uses the most gallons of water in its production and it is the region with the highest water stress.[130] Farmers and anti-fracking activists have come together to protest fracking in California and stress the importance and necessity of conserving water. Fracking has also increased water competition among farmers and the industry. The situation has gotten so severe that the Santa Clara Valley Water District has put in place an unprecedented 20% cutback on treated drinking water. With no sight of alleviation in the near future, cutbacks will soon occur on farms, golf courses, and residential areas. In order to make up for the 20% loss, water companies will

[128] "Overview of Greenhouse Gases," 2013
[129] Miller, 2013
[130] Freyman, 2014, 59-62

have to increase groundwater drilling by 20%, an area of concern in Los Angeles and Kern counties where groundwater may be contaminated due to fracking procedures.[131]

Another area of concern is the amount of wastewater, or produced water, that arises from fracking that can cause surface and groundwater contamination. After the initial fracking process if completed, well pressure is released and water flows back to the earth's surface, called flowback. A certain amount of the fracturing fluid stays underground and over a long period of time presents itself in the ground, known as produced water or wastewater. Both flowback and wastewater are stored at the fracking site in large tanks or pits before they are disposed of or reused.[132] According to a DOGGR report, California produced 16 times more wastewater than crude oil.[133] Produced water contains natural contaminants from under the earth's surface such as inorganic and organic chemicals, radioactive material, and salt.

Groundwater contamination occurs when fracking chemicals escape well bores that are not sealed or have deteriorating casing or and can also escape from abandoned wells. Furthermore, the vibrations and extreme pressures associated with fracking can cause short-term effects to groundwater. Groundwater also becomes contaminated due to the management of wastewater in unlined or deteriorating pits. From the pits, wastewater is transporter to Class II injection wells, which are much less regulated than Class I injection wells thus providing a greater chance of groundwater contamination. Intentional and accidental leaks of fracking fluid, flowback, and wastewater are possible at various stages in the fracking process such as through equipment failure of storage tanks and

[131] Rogers, 2014
[132] Cooley & Donnelly, 2012, 3
[133] Kustic, 2013

improper disposal of wastewater in drinking water sources. [134] In one highly publicized incident, the EPA linked fracking to the leakage of methane into drinking water in Dimock, Pennsylvania, causing significant damage.[135] More studies need to be conducted in order to make definite conclusions, but it is a fracking impact that California regulators should be aware of and concerned about.

[134] Cooley & Donnelly, 2012, 23-27
[135] Drajem, 2013

Chapter 7: The Economics of Fracking

The growth in oil extraction techniques, namely fracking, within the past few years has opened a new door for industry growth. The discovery of the vast size of California's Monterey Shale has many pro-frackers excited about potential economic growth in the state. In addition to creating thousands of instate jobs and employment opportunities, it would aid the California's economy by reducing the amount of oil it imports and could potentially increase exports for the nation. Reducing the nation's foreign imports would be a step in the right direction in decreasing foreign oil dependency and increasing energy security.

A collaborative report by the U.S. Energy Information Administration (EIA) and International Energy Consultants (INTEK) in early 2011 initially estimated that the formation contained as much as 15.4 billion barrels of recoverable tight oil, which accounts for almost two-thirds of the estimated total tight oil reserves in the entire nation. Although the EIA/INTEK later revised the estimates to 13.7 billion barrels, the focus has largely been on the original number. This colossal estimate inspired a University of Southern California (USC) study of the economic benefit if this amount of oil was indeed produced in March 2013. Using economic modeling techniques, researchers found that fracking the Monterey Shale could create anywhere from 512,000 to 2.8 million new state jobs annually, stimulate economic growth by increasing California's GDP by 2.6-14.3%, increase personal income by an average of 2.1-10.0%, and lastly, could boost the state and local governments by $4.5 billion to $24.6 billion.[136] The significant variation in the estimated economic impacts leads to skepticism about the validity of the report and its

[136] USC, 2013, 4

high level of optimism. Additionally, the report was partially funded by the Western States Petroleum Association (WSPA), a nonprofit trade association whose members include all of the nation's largest oil industry companies. This alone should serve as a red flag indicating a conflict of interest. The oil companies want the public to support the expansion of fracking because they will reap the majority of the benefits.

California State University Fresno released another report in August 2013 analyzing the current and future economic impact of oil and gas production in the Monterey Shale on the San Joaquin Valley. The second half of the study, *The Potential Economic Impact of Oil Production from the Monterey Shale Formation,* is of particular interest to this analysis. Researchers used dynamic linear models similar to the methodology used in the USC study to estimate GDP per capita, employment, income, and tax revenue for the next 15 years or so. The analysis uses two different scenarios—a high resource scenario based on EIA estimates and a high-resource-oil boom scenario based on oil production growth observed in the Baaken play in North Dakota. The results of the forecasts are shown in Table 1 below.[137]

Table 1. The various economic impacts of oil and gas production from the Monterey Shale on the San Joaquin Valley.

	High Resource Scenario	**High Resource-Oil Boom Scenario**
Job Gains	2,151-34,485	2,151-195,683
Personal Income Growth	$201 million-$4 billion	$201 million-$22.8 billion
Taxable Sales	$74 million-$1.2 billion	$74 million-$6.7 billion
GDP per capita Growth in the San Joaquin Valley	$44-$701	$44-$3,980

[137] Avalos & Vera, 2013, 18

In similar fashion to the estimates of the USC study, the recorded estimates of this study vastly vary demonstrating the uncertainty of how the economics of oil and gas production will fare in the San Joaquin Valley. The study concludes by claiming that forecasting demonstrates that the Monterey Shale Formation could have significant economic benefits to the San Joaquin Valley, but to consider the fact that forecasting techniques are not perfect.[138]

The USC report's estimates were reevaluated in December 2013 in an analysis, *Drilling California: a Reality Check on the Monterey Shale,* conducted by the Post Carbon Institute and Physicians Scientists & Engineers for Healthy Energy (PSE). The author's, J. David Hughes, main criticism is that the EIA/INTEK estimates were based on the assumptions that tight oil production in the Monterey Shale is the same as production of other formations, such as the Eagle Ford play in Texas, and that unanimous production techniques can be used throughout the formation, disregarding the vastly geological differences that exist in the Monterey formation.[139] Thus, because the estimates are inaccurate, USC's conclusions rest on false claims and the Monterey Shale's potential economic contributions need to be reexamined. The previous reports may not have taken into account the fact that many oil and gas wells in the Monterey Shale are inactive, about 40%, a statistic that would have been a significant error in the analyses. Hughes' report extensively analyzes the geology of the shale and well production techniques that were used in the previous reports and concludes that their assessments are over-simplistic due to several overlooked facts. For example, fields in the shale are aerially restricted and board assumptions cannot be made about the areas as a whole. The estimates also use the

[138] Hughes, 2013, 18-25
[139] Hughes, 2013, 30

highest producing wells as the base numbers for production volumes, which thus leads to inaccurate predictions. High-producing wells only represent a small fraction of the total number of wells. The estimates also assume that horizontal drilling, hydraulic fracturing, and acidization will greatly increase well productivity, but an extensive analysis concluded that no such results have been demonstrated. The report concludes by advising Californians to disregard the hype about the Monterey Shale's economic benefit because there is not enough information to make accurate and secure forecasts.[140]

Another concerning economic aspect with regards to expanding fracking is the exemption of oil and gas producers of paying a severance tax, a tax "imposed on the removable of nonrenewable resources such as crude oil, condensate and natural gas, coalbed methane and carbon dioxide."[141] For oil producing states, this translates into a certain tax rate on every barrel of oil. Although other types of property taxes exist, California is the only major oil producing that does not impose a severance tax, not to say that it has not tried to. Since 1981, California has unsuccessfully tried twice to pass a severance tax, most notably in 2006 with the failure of Proposition 87.[142] The issue of a severance tax was reintroduced in February 2014 when State Senator Noreen (D-Santa Rosa) once again proposed Senate Bill 1017, a bill that would tax oil companies by 9.5 percent and would equally distribute 50% of the funds to the University of California, California State University, and California Community College systems, 25% to health and human services, and 25% to state parks. Evans' reasoning for this tax revenue distribution is because of the injustice that oil companies receive millions of dollars a day

[140] Hughes, 2013, 46-47
[141] "Severance tax"
[142] Hiltzik, 2009

from California-owned resources, while the state continues to suffer an increasing debt and growing population.[143] Considering the growth in oil production in the last few years due to fracking and acidization techniques, a severance tax could greatly increase the California's GDP and aid in boosting the struggling economy. The tax rate would not significantly affect the revenues of oil companies and the states' education system, health system, and environment would benefit.

Along with fracking come various unintended costs, such as infrastructure damage caused by transportation requirements and earthquake damage caused by induced seismicity. Fracking produces a large volume of truck traffic due to the need to transport materials and equipment to well sites and transport produced water to wastewater injection wells. The New York State Department of Environmental Conservation estimates that a new single high-pressure fracking well requires 3,950 truck trips. Multiplied by the 12,229[144] active oil and gas wells in the state, results in a little less than 50 million truck trips; however, because most wells are already existing, the actual number is lower, probably closer to 30 million trips. The millions of trips made by heavy trucks can cause serious damage to roads and highways, which in return would require state funding to repair and possibly raise taxes, upsetting California residents.[145] Furthermore, California's infrastructure is already in bad shape. According to the 2013 Report Card for America's Infrastructure, 68% of California's road are in poor condition.[146] Another economic issue of minor concern is the infrastructure and development costs in the event of induced earthquakes. California's recent series of

[143] McGreevy, 2014
[144] FracTracker
[145] Cooley & Donnelly, 2012, 25
[146] Emrani & Kincaid, 2012, 44-51

possibly human-induced earthquakes range from M3.0 to M5.1 and could have the potential to cause millions of dollars in damage.

A study by the National Bureau of Economic Research at Duke University found that property leased to oil and gas companies has significantly reduced property value, mainly because of the risks associated with groundwater contamination. The research was conducted on Pennsylvania property and found that property within 1.25 miles of an on-site well lost 13% of its value. The study suggested "there would be large gains to the housing market from regulations that reduce the risk [of groundwater contamination]."[147] Groundwater contamination risks also lead to another economic concern: groundwater remediation. The groundwater remediation process removes contaminants through active methods that have proven to be quite costly. In California, there are currently 13,000 well sites that have released petroleum from leaking underground storage tanks (UTS) being investigated by the Regional Quality Control Boards and the California Department of Toxic Substances. Costs of remediating the groundwater include "characterizing the groundwater or aquifer, capital cost of the remediation site, and operation and maintenance costs during the life of the project."[148] Depending on the severity and components of the contaminants, the cost to clean up a well site can vary anywhere from $100,00 to $1.5 millions. Since 1989, over $2.3 billion have been distributed by the Underground Storage Tank Cleanup Fund to eligible contaminated sites. Furthermore, sites that contain solvent leaks, a widely common risk in fracking procedures, could require years of treatment that cost millions of dollars. State regulatory agencies have estimated that groundwater remediation costs could reach close to $20 billion in the next

[147] Muehlenbachs, L. et al., 2014, 36
[148] "Groundwater Remediation," 2009, 15-7

several decades.[149] Because of the high risk of groundwater contamination from fracking and the subsequent expensive clean-up procedures, the economic cost of fracking outweighs potential benefits.

[149] "Groundwater Remediation," 2009, 15-7—15-8

Chapter 8: Conclusion

Fracking in California has the potential to produce exorbitant amounts of crude oil and natural gas; however, it is a widely controversial topic because of the observed and measured adverse impacts to the environment, society, and the economy. In its current state, the societal and environmental costs outweigh the potential economic benefits. There is not enough information about how fracking will impact California's environmental future and long-term human health impacts to justify it as a medium of boosting the state's economy and the industry's revenues. Furthermore, the forecasted economic benefits are highly speculative and not high enough to substantiate the associated risks.

From an environmental outlook, fracking causes air and water pollution, which threatens human health, livestock, and the environment. Fracking operations emit various pollutants such as methane, particle pollutants, smog, and other GHGs, which cause respiratory ailments and have been linked to lung cancer. A high proportion of fracking occurs in Southern Californian regions, an area that is already heavily polluted with high levels of smog and ozone. Furthermore, the increasing amounts of emitted GHGs have been linked to climate change and global warming. These pollutants contaminate local water resources used for agriculture, farming, livestock, and drinking and in some documented instances, fracking has caused surrounding residents' water to become flammable. Central California produces most of the state's produce and ironically, is the heaviest fracked area in the state.

Another aspect of serious concern is the high volume of water used in oil drilling operations in the midst of an extreme drought. According to a Ceres report, the average

California well uses 134,000 gallons of water, totaling over 4.5 million gallons of water annually.[150] As fracking continues to expand in the state, the state's water resources will continue to become depleted. Furthermore, the majority of fracking takes place in areas that are in extreme water stress, such as Kern County and other areas in the San Joaquin Valley. Fracking's high water usage has led to significant water competition among owners/operators and farmers. Without water, California farmers cannot irrigate their land, thus cannot sustain yields, leading to economic and possible job losses. Agricultural losses could also mean disruption to the state's economy since California is a major exporter of produce. Fracking can also lead to groundwater, surfacewater, and drinking water contamination due to intentional or accidental leakage of flowback and produced water.

Southern California's recent series of earthquakes has raised serious concerns about the link between fracking and seismicity. Researchers and scientists believe there is a distinct correlation between the proximity of a wastewater injection well and an active fault line that causes induced seismicity. If fracking continues to expand within the state, there will be greater volumes of wastewater generated, thus more instances of wastewater injection at sites. Many believe that this will subsequently increase the frequency of sizeable earthquakes. A recent study concluded that in regions with increased fracking activity such as Oklahoma, Texas, and Ohio there has been parallel increases in earthquake activity. Induced earthquakes can cause hazardous leaks and spills in the fracking process and cause significant and costly damage to the state's infrastructure.

[150] Freyman, 2014, 59

The increase of transportation of crude oil by rail and pipeline raises a significant safety concern in the fracking process. As more and more crude oil is being discovered and fracked, transportation methods also need to increase to distribute it around the nation. In just one year, oil transportation in the U.S. increased 4000%.[151] Rail transportation causes a significant hazard due to the possibility of explosions and accidental derailments that could also lead to explosions. In the past year alone, there have been several recorded instances of crude oil by rail accidents that have caused significant damage and large spills. Additionally, recent discussions of crude oil being transported to the Bay Area from North Dakota and Canada have lawmakers and residents concerned about potential spills and accidents. State Senator Jerry Hill (D-San Mateo) expressed concerns that the Bay Area is not properly prepared or equipped to protect residents from potential disasters that may arise from the high volume of crude oil coming in.[152] Transporting oil by pipelines also poses health and environmental risks because of toxic emissions and spills.

The industrial processes of fracking also pose serious risks for workers on the job. Workers are regularly exposed to dangerous substances such as crystalline silica, exhaust gases, and particulate matter that can cause respiratory ailments and lung damage. Fracking also heavily relies on the use of hydrofluoric acid (HF), one of the most dangerous chemicals used in industrial processes, thus workers are exposed to HF daily. Contact with HF causes skin and eye burns, as well as lung damage with prolonged exposure. Other safety concerns are high noise levels, over exhaustion, and extreme temperatures. In addition to affecting the health of industry workers, fracking also

[151] "Safe Rail Transport," 2014
[152] Ryan, 2014

significantly has adverse health impacts on human and animal health. The hundreds of chemicals used in the process, many of which are toxic to humans, contaminate the air and local water sources. Polluted water can enter the local drinking water and consumption of this water contains radioactive materials that have been linked to cause cancer. Additionally, livestock consume polluted water, greatly affecting the vitality of farms.

Furthermore, the previously stated economic benefits of fracking in California have called for much speculation and doubt. A 2011 EIA/INTEK report estimated that there were 15.4 billion barrels of recoverable oil in the Monterey Shale, a figure used by a USC study to estimate the possible economic growth for the state. The study predicted a huge increase in the number of jobs and a significant increase of the state's GDP, as well as in local governments' revenue stream. A Fresno State Study also reported the possibility of similar impacts in the San Joaquin Valley. However, the estimates and optimism were revaluated by a collaborative report by the Post Carbon Institute and Physicians Scientists & Engineers for Healthy Energy. The report argues that it is nearly impossible that the Monterey Shale will bring as many benefits as proponents of drilling have claimed because the rock formations are unfamiliar and there is not enough information available to make such estimates assertions. California's lack of a severance tax on oil drilling is also a concerning fact because it further increases oil and gas companies to expand their activities, increasing health and environmental risks. Fracking would also cause other economic concerns such as damaged infrastructure, decreasing property values, and costly groundwater remediation processes.

The greatest issue currently facing the fracking debate is the lack of federal and state legislation and regulation. Past federal legislation regarding air pollution, environmental protection, resource conservation, and clean water does not accurately or directly address the risks and legalities concerning fracking, attributed to the fact that the increase in fracking is a recent phenomenon that has only recently received noteworthy attention. For example, the Clean Air Act no longer lists hydrogen sulfide as a hazardous substance, meaning that oil and gas companies do not have to report its use. Additionally, the ambiguities in the Clean Water Act make it difficult to control industry polluters since there is no explicit reference to fracking operations. Because of the real and increasing risks of fracking, it is critical that legislation be amended to include fracking and ensure the safety and protection of human health and the environment.

However, instead of focusing time and money into regulating and controlling the nation's fracking activities, the White House's focus should concentrate on implementing a clean energy economy. President Obama ran his second term emphasizing a detailed plan to combat climate change, both on a national and global level, and to develop and secure U.S. energy resources. The clean energy platform highlights the need for safe and responsible domestic oil and gas production, but from the in-depth analysis of the impacts of fracking in California, it cannot be concluded that fracking is by any means a safe nor responsible way to produce oil and gas resources. Another focus of the platform is on providing consumers with ways to reduce costs and save energy through investments in clean vehicle technologies and updating the energy efficiency mechanism in homes and buildings. Furthermore, President Obama has beckoned Congress to get rid of large oil and gas company tax breaks, which would save taxpayers billions of dollars

and provide funds for further investment into a clean energy future.[153] He also signed an Executive Order that "directs Federal agencies to reduce GHG emissions, meet a number of energy, water, and waste reduction targets, improve the efficiency of vehicle fleets, and leverage Federal purchasing power to promote environmentally-responsible products and technologies."[154] In order to fulfill its plan to implement nationwide sustainability practices, the Obama Administration needs to recognize the obstacles that fracking presents to the plan. Fracking is detrimental to combating climate change due to its contribution to GHG emissions and increasing water contamination, thus Congress should administer a nationwide moratorium on fracking until its exact impacts are pinpointed and instead focus on creating more sustainable means of increasing energy security.

California's legislation and regulations regarding fracking and its impacts are also highly ambiguous and leave room for the oil and gas industry to find loopholes to continue imposing hazardous risks to state residents and the environment. Governor Brown's recent approval of SB 4, a piece of legislation that allows fracking to continue with the obtainment of a permit, severely contradicts his democratic election platform of combating climate change and global warming. Governor Brown's supporters were pushing for a statewide moratorium on fracking, not a legislation that still allows fracking to take place almost as freely as before. Critics and anti-frackers highlight the significant financial contributions that the oil industry gave to Brown's campaigns, thus providing a believable reason for Brown to support fracking. Environmentalists have been long-time supporters of Brown, but his recent decisions have changed the

[153] "Securing American Energy," 2014
[154] "Securing American Energy," 2014

demographics of his supporters who now regard him as a hypocrite.[155] In similar fashion to the Federal Government, Governor Brown's Administration should administer a statewide fracking moratorium until the regulatory study of the impacts in finished and provides conclusive results.

Other Californian cities and communities have introduced legislation that would be a step in the right direction to more effectively regulating fracking and/or towards implementation of a moratorium. In February, Senate Bill 1132 was introduced and would place a moratorium on all fracking until "a comprehensive, independent, and multi-agency review exploring the economic, environmental and public health impacts is complete."[156] Two other bills were introduced a short time later, one that would require the reduction of freshwater use in oil and drilling operations and another that would focus on regulating safe transportation of crude oil by rail into the state. In order to make a lasting impact and influence the Governor's office to be more proactive in regulating fracking, local governments and communities need to take matters into their own hands. Santa Cruz County, San Benito County, Marin County, Berkeley, Carson, Culver City, Los Angeles, and the San Francisco Board of Supervisors have all taken key actions in urging fracking moratoriums and introducing motions to request a ban.[157] It is key for more municipalities to take a stance on fracking in order for the state government to acknowledge the staunch opposition that proliferates local communities, especially those directly affected by fracking. California's regulatory agencies, such as DOGGR, the

[155] Baker, 2014
[156] Bacher, 2014
[157] "Policy: Local Regulations," 2013

BLM, the EPA, and the SCAQMD, also need to take on a greater role in controlling and overseeing fracking operations.

Due to the serious health and environment impacts, the economic ambiguities, and the lack of consistent and efficient legislation and regulation, fracking in California should discontinue until there is more transparency of the oil and gas industry and the exact effects are known. Though the Monterey Shale may potentially contain vast amounts of crude oil and shale gas, the world will run out of natural resources eventually, it is just a matter of time. Thus, as a nation, the U.S. should be the leaders in developing a clean energy economic by investing in the technology to create renewable resources and sustainable energy practices and weaning off of our dependence on crude oil and natural gas.

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