WATERLESS FRACKING: A CLEAN SUBSTITUTE

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INTRODUCTION: 'FRACKING': BENEFITS AND DETRIMENTS

Hydraulic fracturing, more commonly known as fracking, has become a source of much controversy in recent years. Fracking is a process used to release natural gas and other substances from underground rock formations through the use of pressurized fluids. These fluids are pumped into wells to break up the source rocks and extract the valuable natural gasses within them [1]. However, the fluids used are often composed of toxic chemicals that pose a threat to both people and the environment. The resulting fluids that come back to the surface are often not dealt with properly. This has led to intense debate among gas drilling companies, citizens, and environmentalists. The main argument is whether or not the environmental detriment is worth the economic benefits fracking provides.

The benefits of fracking on the economy are too substantial for all fracking operations to be terminated. However, the environmental concerns are also valid and can't be ignored. Therefore, it is necessary to find ways to improve the process to make it both cleaner and safer. This has led to the demand of alternative methods of fracking. One such method involves the substitution of the usual hydraulic fluids with a liquid petroleum gas gel (LPG). This method could prove to be far less taxing on the environment than traditional methods [2].

Having grown up in Pennsylvania, it is very disconcerting to see so much disregard of the effect that fracking has on both people and the environment. However, I also recognize the many crucial economic benefits of hydraulic fracturing. The newly accessible supply of gas could heavily reduce the United States' dependence on foreign oil for decades [1]. Fracking will not be going away anytime soon. Therefore, it is essential to ensure that we are not doing irreparable damage to the environment. Therefore, it is paramount that we implement a cleaner alternative that will reduce environment impact while maintaining economic growth.

Ethics is a very important aspect of this paper. Hydraulic fracturing is in several ways a violation of ethics. As a future an engineer, it is vital that I gain an understanding of the strict professional behavior that will be required of me. According to the National Society of Professional Engineers which has laid out a very explicit code of ethics, this behavior includes virtues such as "honesty, impartiality, fairness, and equity." In addition, the services of an engineer must be done with public's health, safety, and welfare as the highest priority [3].

HYDRAULIC FRACTURING: THE CURRENT PROCESS

OVERVIEW

Hydraulic fracturing is the most common form of gas and oil extraction in the United States. Fracking wells are prevalent throughout the country. They can be found in Pennsylvania, West Virginia, Texas, and several more states. Stretching from New York to Tennessee is the Marcellus Formation. This enormous shale formation has been found to have large amounts of natural gas, particularly methane. It is the primary source of natural gas in the United States.

Gas wells are dug vertically until they reach this formation. At which point they are then drilled horizontally in order to gain access to as much natural gas as possible. Once the well is completely drilled, hydraulic fracturing begins. During this process, a mixture of hundreds of chemicals is injected into the ground. A variety of chemicals is used to ensure the mixture flows sufficiently and there is enough pressure to fracture the rock. Through these fractures the natural gas can flow easily and be pumped back up to the surface. Often the fracking fluids flow back to the surface along with the gas [4].

Many of the fluid chemicals are known to be toxic and some are even carcinogenic. These chemicals include hydrochloric acid, glycol ethers, formaldehyde, and many more. Drilling companies claim that these chemicals make up as little as .5 to 2 percent of the total fracking fluid used in a well. However, several million gallons of water are used in a typical mining operation. A four million gallon supply of fluid would require anywhere from 80 to 330 tons of chemicals [5]. This results in an insurmountable amount of contaminated waste water that needs to be disposed of safely.

DISPOSAL EFFORTS

The EPA estimates that 35,000 wells are fractured yearly in the United States. This would require 70 to 140 billion gallons of water [6]. Reports say anywhere from 25 - 100% of the contaminated fluids return to the surface from Marcellus Shale operations. Furthermore, the flowback not only contains the produced chemicals but also many contaminants from the shale itself. These contaminants include brines, heavy metals, radionuclides, and organics [4].

The new contaminants contribute even more to the expense and difficulty of disposal. The large amounts of salt

and minerals would poison any body of water that the fluids were dumped into. Traditional wastewater treatment facilities are also not an option as they are equipped to handle sewage and storm water runoff rather than water with massive levels of contaminants [7].

This has led to the most common solution of injecting the water down disposal wells. More than 90% of contaminated fluid is disposed this way [7]. This method is not without its own issues however. Reports suggest that the increased volume of underground water can cause enough pressure to cause earthquakes. A large portion of the waste is also stored on the surface either in open pits or large tanks until they can be either recycled or injected into the ground. These methods have thus far been hardly adequate to address the huge amounts of waste produced every day [5].

The ineffective disposal of wastes has inevitably led to spills that have violated surface water quality standards. In October 2008 excessive amounts of gas well brine at public owned treatment works in the Monongahela Basin caused high total dissolved solids (TDS) in the river as well as its tributaries [5]. The reason fracking operations have steadily increased despite these mishaps lies in its economic impact.

The failure to dispose of these very dangerous wastes is a clear violation of the NSPE Code of Ethics which explicitly states engineers "are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations." This challenges engineers to satisfy the human needs for food, shelter, waste management, and more while conserving and protecting the environment for future development [3]

BENEFITS: ECONOMY AND ENERGY

Fracking efforts have only grown in recent years because of the economic boost it has given the country. Studies say fracking had created 600,000 jobs in 2010, a number that could grow to 870,000 in 2015 and 1.6 million by 2035. In addition, shale gas' drilling economic contribution is expected to grow from $76 billion in 2010 to $118 billion in 2015. In 2010 the industry contributed $18.6 billion in tax revenues and will generate $933 billion in tax revenues over the next 25 years [8].

The positive economic effect fracking can have is best seen by looking at the Bakken area of North Dakota. Since fracking was introduced to the state, it has reduced its unemployment rate to the lowest in the country. It also now has a budget surplus allowing it to spend more money on schools and social services [9].

Currently the United States imports 8% of its oil from Venezuela and 45% from the Middle East and North Africa [9]. Estimates vary but all agree that the Marcellus Shale contains several trillion cubic feet of recoverable gasoline. The Marcellus Shale has greatly decreased our dependence on foreign oil and can continue to do so. The positive impact that fracking could have on the United States as a whole is far too great to pass up but the negative impact on the environment could be too devastating to ignore.

LPG: THE ALTERNATIVE

Liquefied petroleum gas, or LPG, is the latest innovation designed to make fracking a more safe and efficient process. LPG is a fluid formed by compressing propane gas into a thick gel. LPG fracking has several advantages over typical hydraulic fracturing. Much like traditional fracking, LPG is pumped into the well in order to break up the rocks and release gas. However, the gel converts back to a gas when sent underground. This allows it to be sucked back out as the natural gas is extracted. Nearly 100% of the LPG is retrieved in this process. This is a major improvement over traditional hydraulic fracturing in which only about 50% of the fluid is usually extracted. No longer does the fracking process result in large amounts of waste that need to be stored on the surface in open pits and tanks which pose an environmental threat [2]. In addition, LPG fracking requires far less resources to clean up the waste. Less equipment and transportation reduces carbon dioxide emissions [10]

According to GasFrac, the company who is pioneering LPG technology, LPG has many advantages over the water-based fluids used by other companies. Among these advantages are a lower viscosity, less surface tension, and a lower specific gravity. Lower viscosity and surface tension means the LPG requires less pressure to be recovered. A lower specific gravity makes the fluid much easier to transport effectively reducing trucking by 90%. Furthermore, it is not as reactive with formation clays and salts meaning is it not as potentially damaging [10].

Unfortunately, LPG drilling is still a new process and may be considered immature by many. Because GasFrac Energy is the only company offering the service at this point, it is very limited. Despite its success thus far, the effects of conventional fracking have been more than enough to cause skepticism and opposition from those vehemently against all gas drilling. The adoption of LPG Fracking would be in accordance with the code of ethics laid out by the Society of Petroleum Engineers. One of their canons specifically states "engineers seek to adopt technical and economical measures to minimize environmental impact" [11]. By continuing to ignore this valuable new development in the industry of fracking, larger engineering firms are acting in an unethical way.

ENGINEERING EDUCATION: WHY WRITING THIS PAPER IS BENEFICIAL TO ME AND OTHERS

There are several ways in which doing this assignment has benefitted me. Assignments such as this, one associated with a current issue in engineering, expose students such as me to practical applications of engineering. Much of the

freshmen curriculum consists of basic fundamentals such as Calculus, Physics, and Chemistry. While these courses are undoubtedly vital for a developing engineer, they do not often provide insight into what kinds of responsibilities professional engineers are tasked with and what predicaments, practical and ethical, they are faced with.

In the late 1990s, many engineering instructors began to see problems with the course curriculum. They believed it was too focused on fundamental courses such as math and sciences and not enough on flexible studies. In the past 10 years the programs of many universities have changed to involve more emphasis on communication, teamwork, use of modern engineering tools, technical writing, and engineering design. In addition, these universities have successfully modified their programs to include these aspects while maintaining the necessary focus on fundamental courses. Studies showed that many of the students subjected program changes were found to be much better prepared to enter their profession [12].

It would be of great value for any other universities' engineering program to implement assignments such as these. Not only do they serve as a great learning tool, but they also serve to help students become more familiar with a much more specific aspect of engineering they may have not been previously exposed to. This is instrumental for students such as me who still have not decided on what field they would like to major in.

CONCLUSION: A WIN-WIN SOLUTION

It is easy to see the superiority of LPG fracking to traditional hydraulic fracturing. It is a significant improvement in every aspect. Not only does it maintain and increase economic benefits but it also virtually eliminates the environmental concerns associated with hydraulic fracturing.

It is paramount that more companies in the oil and gas industry investigate LPG fracking as an alternative in order to reduce their impact on the environment. Hydraulic fracturing poses a threat to both people and the environment due to careless and ineffective waste disposal methods. Waterless fracking eliminates these risks with safer materials and more efficient recovery techniques. LPG is truly a win-win solution for both the economy and the environment.

I have also clarified that implementation of LPG fracking is in direct accordance with code of ethics of both the National Society of Professional Engineers and the Society of Petroleum Engineers. Both of these organizations hold environmental conservation as one of their most important canons. Another canon states that engineers should conduct themselves in a way that enhances their honor and reputation. Supporting the adoption of LPG fracking would do just that.

I have also explained how the entire process of writing this paper is a universally useful assignment for engineering students as it not only helps with writing skills but also exposes them to a more specific perspective field of engineering. It helps them become more acquainted with the work a specific type of engineer does and could draw their attention to pursue that field.

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