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ENERGY OUTLOOK OF THE UNITED STATES: CAN SHALE OIL RESERVES &
HYDRAULIC FRACTURING LEAD TO ENERGY INDEPENDENCE?

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ABSTRACT

This thesis aims to answer an important question: Can the United States become energy independent, and if so, when? This thesis delves into the sources of energy available to the United States, including petroleum, coal, natural gas, nuclear, and renewable energy. Furthermore, it looks into the paths to energy independence, including increasing energy supply and decreasing energy demand. With substantial new opportunities facing the energy industry, including using fracking to extract oil and gas deep under the earth's surface, the United States has a plethora of methods to increase its energy supply in the next decades. A few constraints, particularly environmental concerns and political policies, are currently prohibiting the United States from fully engaging all of its resources. Overall, energy independence is an enthralling debate that will impact where the United States is headed in the future.

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I. Introduction

An ongoing debate regarding energy independence has fixated leaders of the United States for decades. Should the United States become energy independent? Does the United States have enough resources to become energy independent? How long will it take? Questions such as these have fascinated leaders and citizens for decades. With new findings of shale oil and gas reserves and methods to extract it, these questions have become extremely relevant to the United States' energy outlook.

With the surge of natural gas available in the United States, it is important to consider the impact it will have on the United States in the coming decades. Renewable energy is also becoming more abundant, with the government giving tax breaks to individuals and companies that implement environmentally friendly alternatives, such as solar panels and LED lights. This thesis aims to see where the United States is headed in the future, and where it has the potential to go with a vast amount of energy resources.

II. Research Methodology

In conducting my research for this thesis, dozens of articles and journals were read to gain a better understanding of the energy resources the United States currently has and the potential for growth in the future. The topic of energy independence in the United States is an extremely relevant topic and debate that is written about daily. Consequently, news and magazine articles were viewed on a daily basis to continually read about updates and new discoveries. Besides constantly reading newspaper and magazine articles, a literature review was conducted to summarize the findings and focus on the material for this thesis. Using many sources, differing viewpoints were found concerning what the experts thought about energy independence for the United States.

III. Sources of Energy

The United States can use several different sources of energy in its quest to become energy independent. The five major types of energy this thesis will focus on are petroleum, coal, natural gas, nuclear, and renewable energy. Currently almost two-thirds of the United States' energy consumption comes from petroleum and natural gas (United States Renewable Energy, 2012). Coal is the third biggest source, accounting for twenty-one percent of American energy consumption (United States Renewable Energy, 2012). Exhibit 1 shows the breakdown of the total energy consumption in the United States in 2010:

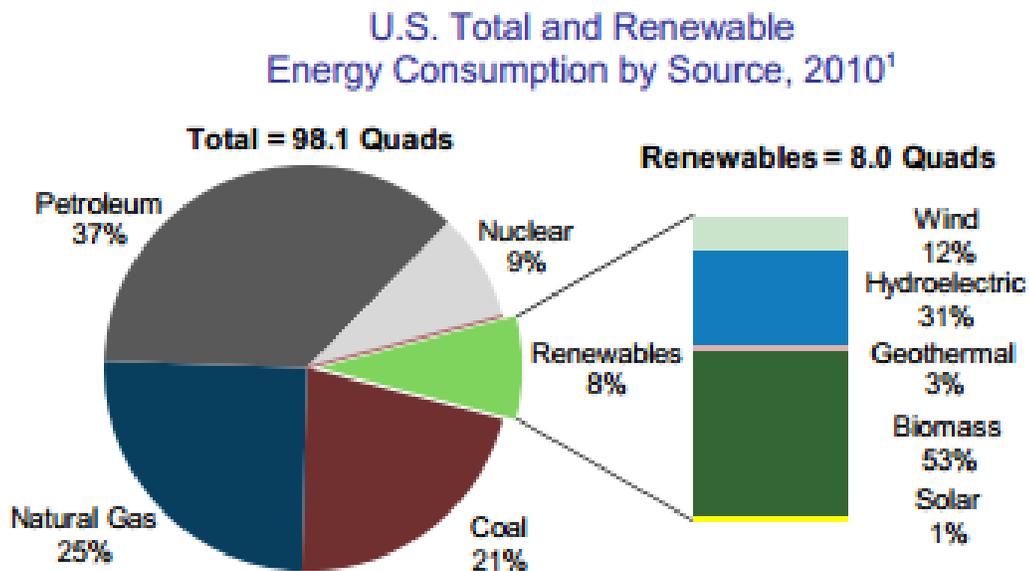


Exhibit 1: United States Energy Consumption by Source (Earthly Issues, 2010)

a) Petroleum

Petroleum, or crude oil, accounts for the largest percentage of United States energy consumption with thirty-seven percent. Petroleum is obtained from under the earth's surface through drilling and installing oil wells. There is a finite supply of petroleum under the earth's surface, which means that eventually it will run out. Petroleum can be turned into gasoline, diesel and jet fuel, asphalt, ethanol, and bio-fuels, among other products (EIA: Independent Statistics and Analysis, 2012). Exhibit 2 below compares the United States crude oil production and consumption over the last thirty years. The trend in the last ten years is the United States produces less than a third of what it consumes (Index Mundi, 2012). In 2010, the United States produced 28.5 percent of what it consumed (Index Mundi, 2012). In order for the United States to become energy independent, it will need to produce more petroleum and import less because currently the United States is using more than it is producing.

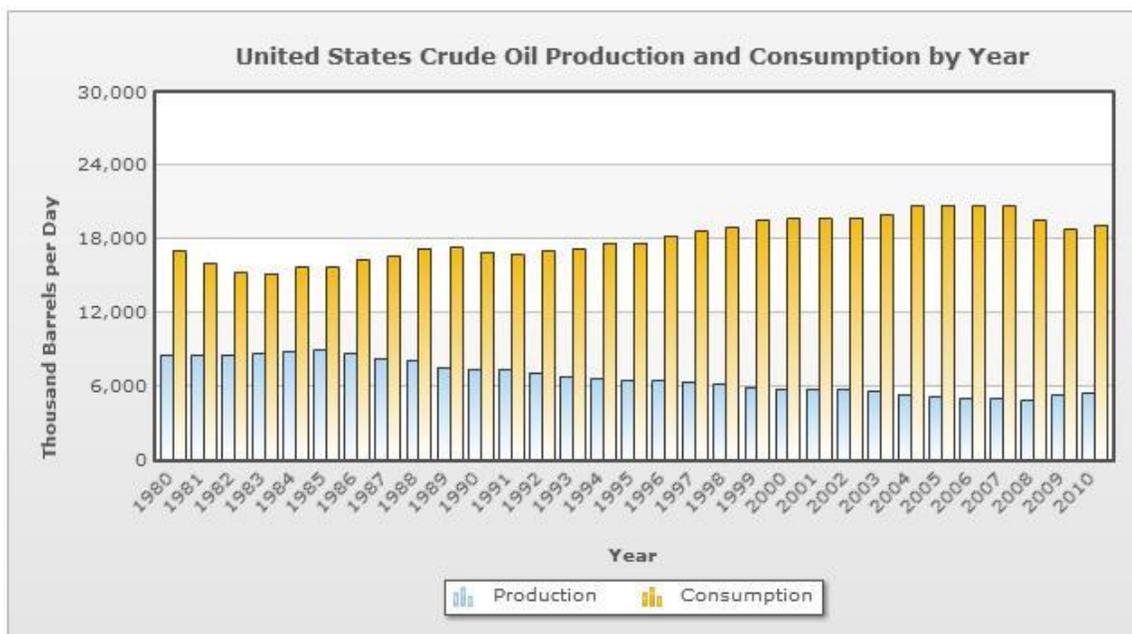


Exhibit 2: United States Crude Oil Production and Consumption by Year (Index Mundi, 2010)

b) Coal

Coal is a fossil fuel that can be burned to produce heat and electricity. It lies under the earth's surface and can be extracting through mining. Within the United States, seventy-two percent of coal is produced by five states: Wyoming (41%), West Virginia (12%), Kentucky (10%), Pennsylvania (5%), and Montana (4%) (EIA: Independent Statistics and Analysis, 2012). According to an article in *Bloomberg Businessweek*, the United States holds the largest reserves of coal in the world (Exports of Coal, 2012). So why is the United States exporting coal if it is not yet energy independent? The answer is simple: the demand for coal in the United States is dropping as it moves toward using renewable energy and natural gas to power electricity and utilities. On the other hand, developing countries are increasing their use of coal because the conversion of coal to electricity is essential for areas where people are just beginning to be able to afford electricity (Exports of Coal, 2012).

c) Natural Gas

Natural gas is another form of energy that is used to make heat and electricity. Additionally, natural gas can be used for furnaces, gasoline in cars, water heaters, hydrogen, and fertilizers. Natural gas accounted for twenty-five percent of the United

States' consumption in 2011. Exhibit 3 below shows the United States' net imports of natural gas from 2002 to 2011 (Exports of Coal, 2012). Net imports mean the total imports minus the total exports, and it is represented by the blue line. As illustrated by the graph, net imports have decreased over the past five years.

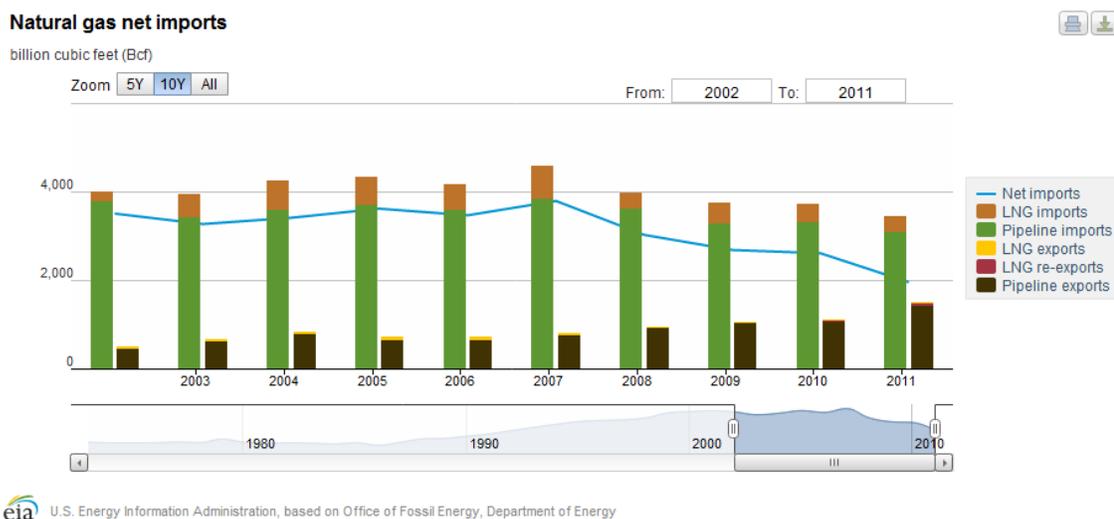


Exhibit 3: Natural Gas Net Imports (United States Energy Information Administration, 2011)

d) Nuclear

Nuclear energy accounted for only nine percent of the United States' total consumption in 2011, but it still plays a role in the United States becoming energy independent. One benefit of nuclear power is that it does not pollute the air or emit greenhouse gases, which can cause global warming (Wired, 2012). Nuclear power occurs when uranium is put in a reactor and nuclear fission is created (Wired, 2012).

Nuclear fission produces energy, which heats water into steam, which then generates the steam power plant to produce electricity (Wired, 2012). Even though nuclear power only makes up eight percent of the world's energy consumption, it is still a key component in reducing carbon dioxide emitted from burning coal and reaching a future with cleaner energy (EIA: Independent Statistics and Analysis, 2012).

e) Renewable

Only eight percent of the United States' energy consumption in 2010 came from renewable energy (United States Renewable Energy, 2012). However, renewable energy will play a substantial role in future decades because the main aspect that sets it apart from all other sources of energy is that it can be continually replenished. The main drawback of using renewable energy is the heightened costs. This thesis will focus on five types of renewable energy: biomass, hydroelectric, wind, geothermal, and solar.

Biomass power is produced by paper and wood waste products that are converted to energy. This also includes plants and crops. Tree and plants can continually be grown, which allows for replenishment of biomass power, thus avoiding depletion of valuable natural resources. Hydroelectric power is created when water is converted to electricity. Since water is the largest natural resource on earth, hydroelectric power has the potential to grow significantly. Wind power uses turbines to create energy. The blades on turbines rotate with the wind, which creates energy that is turned into electricity. One benefit of wind power is that wind is free, but a drawback is the costly turbines that have to be build first. Geothermal power uses heat from under the Earth's

surface to generate electricity and heat. Geothermal power is becoming a popular source of energy for homebuilders and businesses that want to reduce heating costs. Cost reductions in the long run are a main benefit of using geothermal power. Finally, solar power is a fifth source of renewable energy, which converts the sun's heat to energy. According to an article published by the University of Michigan, "Assuming intermediate efficiency, solar photovoltaic (PV) modules covering 0.4% of United States land area could supply all of the nation's electricity" (United States Renewable Energy, 2012). Clearly solar power has vast potential, but the costs to build solar panels currently outweigh the benefits.

IV. Paths to Energy Independence

a) Increasing Energy Supply

In order to make progress toward energy independence, the United States has two options: it can increase energy supply or decrease energy demand. With fracking, the United States has the opportunity to drastically increase natural gas production. Since 2009, the United States has already increased natural gas production by eighteen percent, and there is potential to increase that percentage even more if fracking is allowed across the United States (Phillips, 2012). According to an article titled "United States Energy Independence is Almost Here" from *Bloomberg Businessweek*, "oil and natural gas production in the United States is increasing at its fastest rate in fifty years, while imports have been cut by a quarter in the last four years" (Phillips, 2012). Additionally, with an

increased supply of crude oil in the United States, exporting oil to foreign countries is becoming a reality. Contingent on their permits being approved, six of the major oil companies want to export oil to Canada (Curwood, 2012). According to Steve Curwood, an author from Harvard, this breakthrough “would mark the first time in decades that significant amounts of United States energy is sent abroad” (Curwood, 2012). Joe Stanislaw agrees and added, “There’s a different mindset in the world of energy today than there was five years ago or 10 years ago. The United States is producing more and more oil and more and more natural gas. We’re going from a mindset of scarcity to, not surplus, but to real supply potential in the United States.” Clearly, energy supply in the United States is increasing, and if it continues to increase with new technology and a boost in fracking, then the possibilities for the United States are endless in the coming decades.

b) Decreasing Energy Demand

Alternatively, the United States can also decrease its demand for energy. There are several ways this can occur, including raising standards for more fuel efficient vehicles, creating more environmentally friendly lighting options, and de-energizing appliances when not in use.

First, if there are more regulations in the automobile industry that require car manufacturers to increase the minimum miles per gallon each type of car must have, then consumers will not have to fuel their car as often, and alternative sources of energy can be used as fuel. For example, hybrid cars have increased in popularity in the last decade

because they are comprised of both a gasoline engine and an electric power source that can recharge the car by using electricity. With the recent discoveries of deeper natural reserves (such as shale), natural gas may provide the most economical source of fuel for automobiles. Natural gas is being used to fuel automobiles in some European countries and in limited areas of the United States. In an effort to increase the use of natural gas, natural gas refueling stations need to be built. These stations could be built with either funding by private industry or by the government. Perhaps the best solution would be a cooperative joint venture with private industry and the government working together.

Another way the United States can decrease its energy demand is by using energy efficient lighting options across the country. Electric lighting bulbs, such as LED (light emitting diode) and CFL (compact fluorescent lights) are two alternatives to regular light bulbs. These two options have longer lifecycles and use less electricity. The results of a 2012 study by Northeast Group LLC showed that “95% of cities that have tried LED streetlights are satisfied with the results, savings nearly 60% in costs” (Roberts, 2012). However, only one percent of United States’ streetlights currently have LED bulbs. Clearly, there is a huge opportunity to increase the use of LED bulbs, which will decrease electricity, and ultimately decrease energy demand in the United States. Additionally, if appliances are unplugged when not in use, this saves electricity, which will not only decrease electric bills, but also decrease energy demand.

V. Fracking & New Opportunities

Hydraulic fracturing, more commonly known as fracking, is a new method of obtaining oil from below the Earth's surface. Fracking occurs when a vertical well is drilled several hundred feet into the ground and then drills horizontally. Fluid is pumped down at a high pressure which essentially explodes the rocks, releasing the shale gas or petroleum (How Fracking Works, 2012). Fracking is pertinent in Texas, where Eagle Ford Shale and Barnett Shale are located, and five northeastern states, where Marcellus Shale is located (How Fracking Works, 2012). This thesis will focus on these three shale discoveries, as they are the largest in the United States and have the biggest potential for producing the most gas. Exhibit 4 below is a diagram of the process of fracking. As illustrated, the shale gas is blasted and then it flows into the horizontal well up through the vertical well.

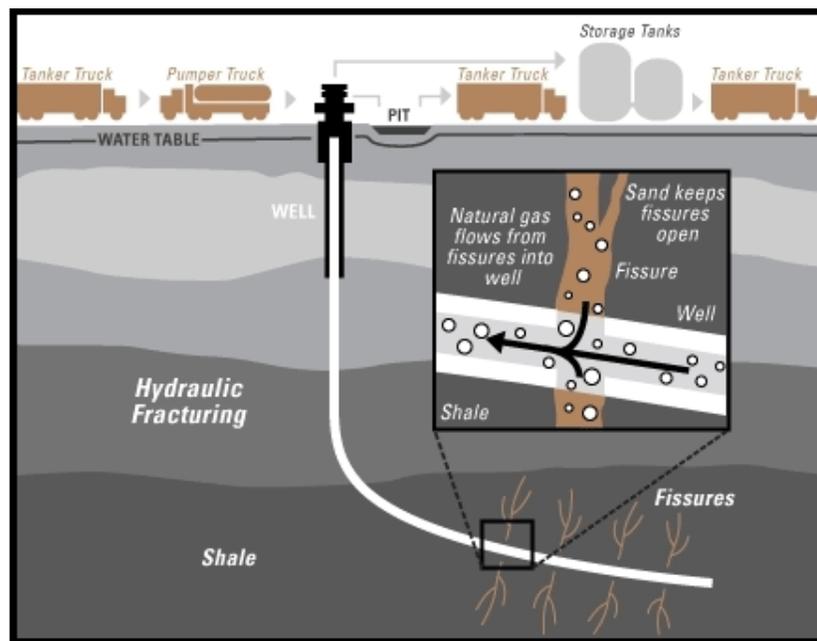


Exhibit 4: How Hydraulic Fracturing Works (Hydraulic Fracturing, 2011)

Currently, environmental concerns about fracking exist; some believe shale gas extraction via fracking harms the environment by contaminating ground water, reducing air quality, and creating additional waste that will not be disposed of properly. However, academic experts and oil executives disagree that fracking is harmful. Dr. Charles Groat, Director of the Center for International Energy and Environmental Policy at the University of Texas, agrees that fracking in itself is not harmful to the environment. He stated, “Drilling for natural gas in itself doesn’t pose a threat to air and water quality, if it’s done properly” (How Fracking Works, 2012). In fact, eighty-eight percent of oil executives agreed that the fracking process is indeed safe or “will become safe as the kinks get worked out” (Moreno, 2012). Even though the media is creating concerns that fracking is harmful, it is evident that experts in the energy, environment, and oil fields disagree and see fracking as harmless.

a) Marcellus Shale

The discovery of shale gas has been a game changer in the United States’ quest to become energy independent. Robin West, chairman and CEO of PFC Energy stated, “This shale gas, I describe it as the energy equivalent of the Berlin Wall coming down. This is a big deal” (Ydstie, 2012). Improvements in technology and the increasing demand for natural gas make shale formations especially appealing in today’s world. As previously noted, shale gas is “natural gas that is trapped within shale formations” (EIA, 2012). Shale formations can be blasted through fracking and shale gas can then be extracted. First drilled into in 2003, the Marcellus Shale formation is found in four

northeastern states, including Ohio, Pennsylvania, West Virginia, and New York. It is approximately “54,000 square miles” and is estimated to contain “500 trillion cubic feet of gas” (Packer, DeRuschi, 2012). Comparatively, the United States on average uses “23 trillion cubic feet per year” (Packer, DeRuschi, 2012). Taking into account these two numbers, this means that if the United States used only natural gas extracted from the Marcellus Shale formation, it could be self sufficient on natural gas for 21.7 years. Clearly, shale gas extracted through fracking has the enormous potential to impact the United States’ natural gas production, which could drastically catapult the United States to energy independence in the near future.

b) Eagle Ford Shale

Discovered in 2008, the Eagle Ford Shale formation is located in South Texas, where it obtained its name from the town of Eagle Ford, Texas. Significantly smaller than the Marcellus Shale formation, the Eagle Ford formation is about 3,000 square miles (How Fracking Works, 2012). Additionally, Eagle Ford Shale has approximately “20.81 trillion cubic feet of natural gas and 3.351 billion barrels of oil” (How Fracking Works, 2012).

c) Barnett Shale

The Barnett Shale formation is located in North Texas and is slightly larger than the Eagle Ford Shale formation, at 5,000 square miles (Barnett Shale, 2012). With the

recent advances in technology, such as fracking, the Barnett Shale formation has an abundance of natural gas that can be extracted. As illustrated by Exhibit 5 below, 10.8 trillion cubic feet of gas have been extracted from the Barnett Shale since 1993. Looking closer at the graph, seventy-six percent of the gas was produced from 2008 – 2011, which shows the significant increase in production over the past few years.

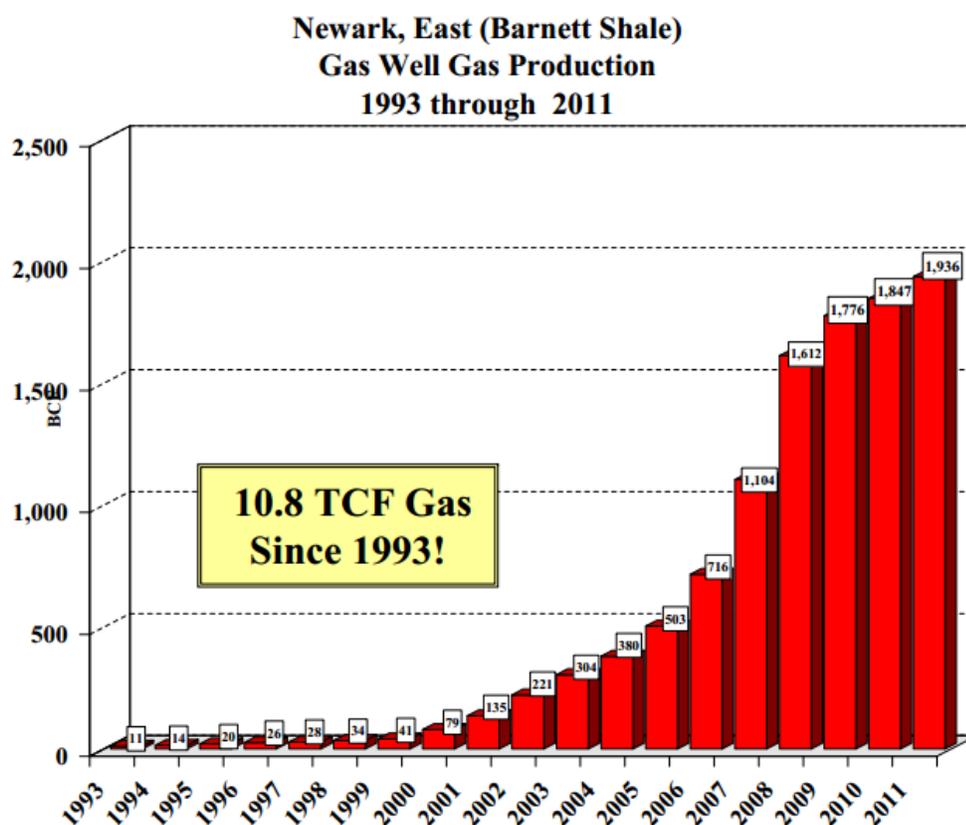


Exhibit 5: Barnett Shale Gas Production (Energy & Capital, 2012)

VI. Constraints: Why isn't the UNITED STATES already using all its resources?

A key question is: why is the United States importing oil and gas from other countries when we are not fully using all of our resources? There are three main constraints prohibiting the United States from becoming energy independent: environmental concerns, lack of technology, and politics.

a) Environment

One huge constraint that is keeping the United States from being energy independent is concerns of harm to the environment from practices such as fracking. Many passionate environmental groups protest against certain ways of extracting oil and gas, such as fracking, because they feel it has a negative impact on the environment and surrounding towns. The main concerns pertain to carbon dioxide (CO₂) emissions.

Looking at CO₂ emissions over the last twenty years, there has been a decline and CO₂ emissions are at the lowest point since 1992. Exhibit 6 from the Energy Information Administration shows the United States' first quarter carbon dioxide emissions for the last twenty years, in million metric tons:

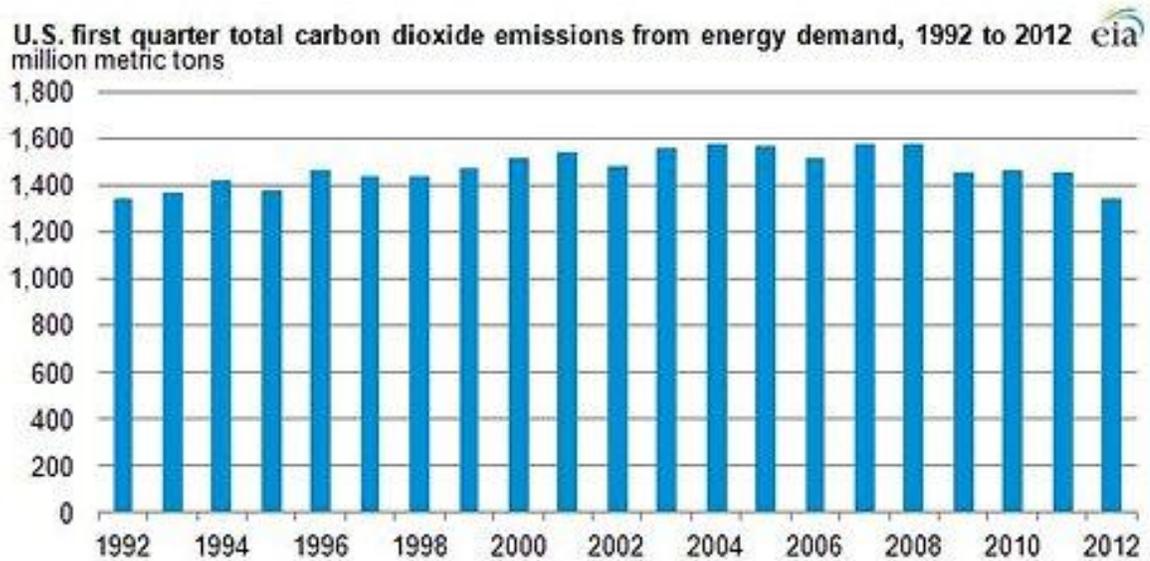


Exhibit 6: Carbon Dioxide Emissions from Energy Demand (Financial Sense, 2012)

According to the Energy Information Administration, the United States has seen a 2.4% drop in carbon dioxide emissions from 2010 to 2011, and a 9.1% decrease since 2007 (Nuwer, 2012). As evidenced by this chart, carbon dioxide emissions should not be a huge concern because even with increased fracking, the percentage change of CO₂ emissions has decreased.

b) Technology

In addition, technology is a constraint in the United States' quest to become energy independent. Technological advances will be crucial for the United States to refine its oil and gas extraction processes. If the United States can develop new technologies and improve fracking, it will gain an advantage in the global market.

According to Joe Stanislaw, an economist and Harvard graduate, "horizontal drilling and

fracking together have changed the game” (Curwood, 2012). Even though fracking has given the United States the undoubted potential to produce more natural gas, technology will need to be continuously improved in order to stay competitive in the global marketplace.

c) Politics

Another constraint is the policies put in place by the United States government. For example, many are concerned that all of the United States’ resources will be exhausted, and then we will face full dependence on foreign countries for oil. For this reason the government has put restraints on where oil companies can drill. For example, the Arctic National Wildlife Refuge in Alaska is restricted from drilling (World Oil Reserves, 2012). This policy also has underlying environmental issues because there is concern that wildlife in Alaska will be harmed by the effects of the drilling. However, drilling is allowed in the majority of oil reserves. In fact, only fifteen percent of America’s oil reserves are fully protected by the government, while fifty-seven percent are fully open to drilling (World Oil Reserves, 2012).

VII. Implications of the 2012 Presidential Election

The United States’ quest to become energy independent will be significantly impacted by the results of the 2012 presidential election. The two main contenders, Mitt

Romney and Barack Obama, have drastically different viewpoints about energy usage in the United States. Mitt Romney believes North America (the United States, Canada, and Mexico) can become energy independent by 2020 by following his plan, while Barack Obama has a more safety conscious approach that will protect the environment. In short, Romney's focus is making the United States an "energy superpower," while Obama's main focus is investing in green energy sources (The Romney Plan, 2012).

a) Mitt Romney's Plan

The main goal of Mitt Romney's energy plan is to increase the United States' power in the energy sector and decrease its dependence on foreign countries for sources of energy. He sums up his plan by stating:

"An affordable, reliable supply of energy is crucial to America's economic future. I have a vision for an America that is an energy superpower, rapidly increasing our own production and partnering with our allies Canada and Mexico to achieve energy independence on this continent. If I am elected president, that vision will become a reality by the end of my second term."

In order to make his plan a reality, Romney seeks to increase domestic production of oil by "empowering states to control onshore energy development, open offshore areas for energy development, and facilitating private-sector-led development of new energy technologies" (The Romney Plan, 2012). He believes that increasing domestic production of energy will lead to three million new jobs, \$1 trillion in revenue for the government (which will decrease the national deficit), increased national security, and an

economic burst that will add \$500 billion to the United States' Gross Domestic Product (The Romney Plan, 2012). He further reiterates the need to become energy independent by stating:

“We have an unprecedented opportunity to make our natural resources a long-term source of competitive advantage for our nation. If we develop these resources to the fullest, we will not only guarantee ourselves an affordable and reliable supply of energy, but also enjoy benefits throughout our economy.”

As evidenced by his statements, his main focus is on increasing energy supply in the United States. First, he plans to “empower states to control onshore energy development.” Right now, sixty percent (165.9 million acres) of land in the United States is not allowed to be drilled. Additionally, this land contains an estimated sixty-two percent (nineteen billion barrels) of oil in the United States and forty-one percent (94.5 trillion cubic feet) of natural gas (The Romney Plan, 2012). Therefore, the majority of land is under regulations that prohibit drilling. Mitt Romney plans to change that by expanding the acreage that can be drilled, which will lead to more oil production.

Another key aspect of Romney's plan is to open offshore areas for energy development. Romney encourages the exploration of untapped offshore locations in the United States; however, he also demands that safety is a priority in offshore drilling (The Romney Plan, 2012). Specifically, Romney wants to allow offshore drilling in areas “off the coast of Virginia and the Carolinas,” which have previously been off limits for drilling. Production of oil would increase if the amount of land allotted for drilling increases.

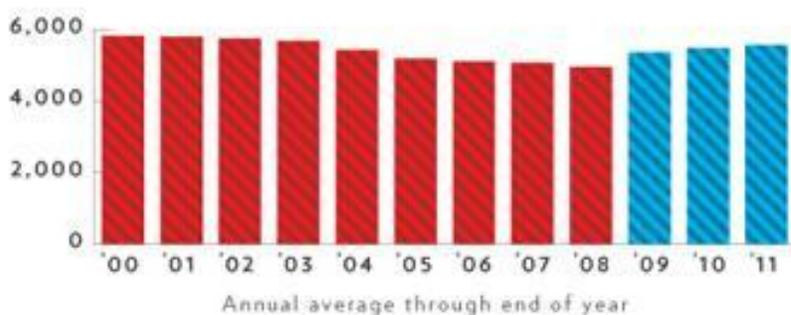
Finally, Romney wants to encourage advancements in new energy technologies within the private sector. If elected, he will invest money in developing technologies for all energy types, not just oil and natural gas. He wants to see improvements in renewable energy technology as well as exploration technology for oil, gas, and coal (The Romney Plan, 2012). Overall, his main focus is to increase the supply of energy in the United States, which will give it more freedom from foreign countries and will make it a dominating force in the energy sector. According to the article “The Romney Plan For A Stronger Middle Class,” experts agree that the United States has a realistic chance of becoming energy independent by 2020. The article states, “Analysts across the spectrum – energy experts, investment firms, even academics at Harvard University – now recognize that surging United States energy production, combined with the resources of America’s neighbors, can meet all of the continent’s energy needs within a decade” (The Romney Plan, 2012).

b) Barack Obama’s Plan

Barack Obama agrees that energy supply needs to be increased in the United States; however, his main focus is on increasing renewable energy sources rather than oil, gas, and coal resources. He refers to his plan as an “all-of-the-above” approach, which focuses on “safely developing” the United States’ natural gas resources, increasing fuel efficiency in vehicles and increasing acreage for onshore and offshore drilling (The White House, 2012). As previously mentioned, he adamantly wants to focus on developing green technologies to further develop renewable energy. His past record

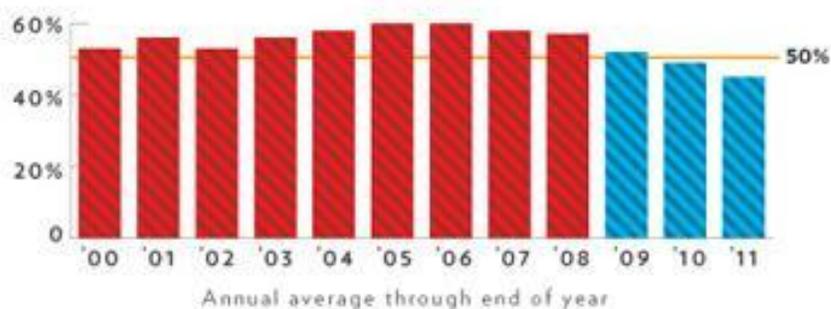
shows that he indeed has increased oil production in the United States and concurrently decreased the United States' dependence on foreign countries for oil. As illustrated by Exhibit 7 below (the blue columns denoting the years that Obama has been President), the change in oil production has a positive trend over the past three years and net imports of foreign oil have slightly declined as well (The White House, 2012).

U.S. PRODUCTION OF OIL RISING UNDER OBAMA
Domestic production of crude oil - thousands of barrels per day



SOURCE: EIA

U.S. DEPENDENCE ON FOREIGN OIL DECLINING
Net imports as a share of domestic consumption



SOURCE: EIA

Exhibit 7: United States Production of Oil / Dependence on Foreign Oil

(www.barackobama.com)

President Barack Obama summarizes his energy views and his “all-of-the-above” strategy by stating:

“If we are going to control our energy future, then we’ve got to have an all-of-the-above strategy. We’ve got to develop every source of American energy – not just oil and gas, but wind power and solar power, nuclear power, bio-fuels: We need to invest in the technology that will help us use less oil in our cars and our trucks, in our buildings, in our factories. That’s the only solution to the challenge” (The White House, 2012).

Overall, Obama seeks to mitigate climate change and increase environmental regulations to ensure safety to surrounding communities. His plan has an overarching environmental focus that promotes the use of renewable energy, and his spending encourages developing new technologies that will lessen environmental harm and increase sustainability. A substantial factor that differentiates Obama’s and Romney’s energy plans is that Obama focuses on implementing regulations for oil companies, while Romney wants to give oil companies more freedom for exploration and development. Despite their differences, the two candidates can agree on one item – the United States needs to increase its energy production in the coming years.

VIII. What the Experts Think

What do the experts think about energy independence for the United States? Phil Verleger, an energy economist, believes that “energy self-sufficiency is now in sight” and “within a decade, the United States will no longer need to import crude oil and will be a

natural gas exporter” (Ydstie, 2012). Furthermore, Amy Myers Jaffe, the director of the Baker Institute Energy Forum at Rice University, considers energy independence a reachable goal in the next decade, with a new policy in place that supports development in energy technology. She stated that this policy “would include continuing the green light on developing shale oil and gas, while making sure it is done in an environmentally safe manner and continuing to require higher fuel efficiency in cars and trucks” (Ydstie, 2012). Jaffe made a key point in her assertion by stating that the future of energy production must be environmentally sound in order to be successful. If the public and environmental outreach groups are not convinced that fracking is safe, there will be a huge pushback to end fracking. According to Angelos Damaskos, CEO of Sector Investment Managers and an expert in natural resources, “it is clear that extensive studies of the potential dangers from fracking have provided no conclusive evidence of damage to health or the environment” (Damaskos, 2012).

Joe Stanislow, a Harvard graduate and former President of Cambridge Energy Research Associates, agrees that energy independence is not only attainable, but not far away. He firmly believes if energy independence is a goal for the United States, it could happen within the next two decades. He stated, “true energy sufficiency is a few years out. In North America, perhaps as soon as 2020. In the United States, perhaps as soon as 2025 or 2030” (Curwood, 2012). Experts in the oil and environmental industry, along with economists seem to agree on one idea: the United States has the potential to become energy independent within a reasonable time period of 2030.

IX. Conclusion

In order for the United States to become energy independent, fundamentally one of two conditions must be met (or both): the United States must either increase energy supply or decrease energy demand. Supply can be increased if the government and citizens are willing to accept the consequences, such as potential harm to the environment.

Looking at the five major types of energy, increasing the supply of each is possible, but could have potential negative consequences. Increasing the use of petroleum requires accepting a certain amount of risk for environmental harm. For example, another scenario mimicking the deepwater oil spill that occurred in the Gulf of Mexico in April 2010 could occur with an increase in petroleum production. However, it is realistic that the devastation caused by an absence of safety precautions has taught major oil companies a crucial lesson – safety is paramount (for a company's reputation and to preserve the environment).

Increasing the use of coal may be beneficial due to its low cost, but it is quickly depleting and it has the lowest energy density (less energy per unit) of the five major energy sources. Furthermore, coal creates air pollution and emits greenhouse gases, specifically carbon dioxide, which has harmful effects on the environment.

Increasing natural gas production may be a promising approach that can lead to the United States becoming energy independent. There is an abundance of natural gas in the United States and it is also the cleanest burning fuel of the five major energy sources.

A main disadvantage is the emission of carbon dioxide; however it releases less carbon dioxide than either oil or coal.

Increasing nuclear power would be beneficial to the environment because it has almost no greenhouse gas emissions; however, nuclear plants are extremely expensive. Another threat of nuclear plants is explosions can occur, as was evidenced in Japan in March 2011, when a tsunami caused a nuclear explosion that released radiation, which is potentially deadly with long exposures.

Finally, increasing renewable energy would help the environment, but it is extremely costly and new technology still needs to be developed for it to be considered practical for average Americans. At its core, using renewable energy seems ideal because it can be recycled and has almost zero impact on the environment. On the other hand, the amount of electricity generated by renewable energy sources, such as solar and wind power, is minimal compared to the amount of electricity generated by oil, coal, and gas. Another challenge is that most renewable energy is dependent on outside factors, such as weather conditions. For example, solar power is dependent on the sun for energy and it is impossible to predict when the sun will shine and when it will be cloudy. For this reason, renewable energy is an inconsistent source of supply because it relies on uncontrollable factors, such as the sun shining for solar power, the wind blowing for wind turbines, and rain falling for hydroelectric power to be generated.

After weighing some potential negative consequences of increasing domestic energy supply, one must consider which of the five energy sources has the most potential. Analyzing each of the five major types of energy reveals that each has a different potential for increased production. Looking at the year 2011, the United States produced

eighty-three percent of the energy it consumed, an increase from 73.9% in 2008 (Phillips, 2012). In only three years, this percentage has increased over nine percent, which proves the United States is on the road to becoming energy independent. Additionally, the percentage of each major source of energy produced domestically compared to the amount consumed varies. Only 28.5% of the petroleum consumed domestically is produced domestically. All of the coal used domestically is produced domestically; additionally some of the coal produced domestically is exported. All of the natural gas consumed domestically is produced domestically. All of the nuclear energy consumed domestically is produced domestically. All of the renewable energy consumed domestically is produced domestically. Therefore, it can be concluded that the path to energy independence requires special attention being placed on the balance of petroleum supply and demand. Petroleum is largely refined into gasoline and used as fuel for vehicles; consequently, alternatives to gasoline powered vehicles must be developed in order to decrease demand. Improving and increasing production of natural gas powered vehicles offers the best solution to decreasing petroleum demand, but gas refueling stations would need to be built, which is a huge capital expenditure.

In conclusion, the key to energy independence for the United States is to reduce oil imports, which is the one source of energy that is largely imported. The main way to reduce oil imports is to convert cars and trucks to an alternative source of energy, besides petroleum. Natural gas or electric batteries are both feasible substitutes for oil; the main drawback is that refueling stations would have to be built at a substantial cost to the United States. Currently there are 519 compressed natural gas stations in the United States and 4,592 electric refueling stations (AFDC, 2012). With the recent surge in

natural gas supply due to fracking and other technological advancements, energy independence is realistically possible in the next two decades. The United States' natural gas production in 2011 was the highest it has ever seen, with the previous record being set in 1973 (The White House, 2012). Furthermore, electric batteries are recharged by electricity, which is largely a product of coal, natural gas, or nuclear power, or hydroelectric power. These sources are in abundant supply and can be easily converted to electricity if citizens believe the benefits outweigh potential negative environmental consequences. With the recent extraction of natural gas from shale, the United States now has the leverage to become an energy powerhouse and to sever its dependence on foreign countries.

The answer to energy independence is to enact all the potential solutions to some degree. Energy supply needs to be increased. Energy demand needs to be decreased. Automobiles need to be fueled by sources other than petroleum. Increased importance needs to be placed on renewable energy sources, and more money needs to be provided by the government and citizens to invest in renewable sources that already exist, such as solar panels and wind turbines. The government should continue to give tax incentives for appliance upgrades, lighting upgrades, and for purchasing more fuel efficient vehicles. Additionally, stricter policies for automobile companies need to be enforced for creating more environmental friendly cars and trucks, such as hybrids. Finally, by educating the public that practices such as fracking are not harmful to the environment, by investing in the development of new technologies, and by decreasing political restrictions placed on drilling, the United States has the resources to become energy independent by 2030.

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