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USA vs CHINA; ENERGY SECURITY POLITICS Challenges of Peak-Oil and Climate Change

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USA vs CHINA: ENERGY SECURITY POLITICS
Challenges of Peak-Oil and Climate Change

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Abstract.

Energy is a critical basis for state survival. This thesis aims at examining the different energy-security strategies of the USA and China and the political means necessary to implement clean-energy development beyond marginal results. The success of China's lead in its devotion to clean-energy production raises the question of what infrastructural and political challenges the US must overcome to further develop its clean energy industry. While China focuses on its competitive edge in the global energy market, can its domestic energy goals offset population density and addiction to coal? Despite economic competitiveness that comes with market globalization, society's only means towards creating innovative and efficient clean energy is sharing new technology and determined political action of states. This can be seen within various leading economies whose energy industries merge with those abroad. The US and China are no exception to the need for transnational cooperation to develop clean energy. As China realizes the benefits of a liberal energy market, this can create opportunity for the Sino-US relations to strengthen for the greater good of cooperation to develop clean energy technology.

Chapter 1. Introduction

I. Energy Sources and Their Significance.

Humans have learned to harvest energy from the natural world in ways that have revolutionized society. Ever since the Industrial Revolution societies have become increasingly addicted to the lifestyle cheap energy has made possible. From large scale industries and technological breakthroughs to the every day needs of people, energy helped shape the world as we know it. The root of all modern industrial success is cheap energy.

Unfortunately, cheap energy provided by fossil fuels is running out. Meanwhile, the global economy is unprecedentedly productive, and new centers of economic power have emerged (India and Brazil, for example), creating additional demand for oil. This means that the competition for oil will become even more intense, with the two largest economies, the US and China, which are also political rivals, at the forefront of the scramble.

Oil is prized for being both energy dense (energy per unit mass) and versatile. It has a greater energy output per unit than any other source and is the easiest to store at room temperature and transport safely over great distances. Because of its value and the profits available to exporting states, the physical limitations of oil being a finite resource have been avoided. Conventional extraction methods such as production from underground fields are now yielding diminishing returns as most of the easily accessible deposits have been, or are being, tapped. This has inaugurated what is known as the era of peak oil.

While American domestic production peaked in the late 1970s, the question of when global reserves will start to reach their maximum output levels remains unclear. This lack of

clarity exits because the world's largest reserves are nationalized and controlled by governments that are reluctant to reveal actual field output numbers. There is, however, increasing evidence of world oil peak in effect, including unexplainable oil market volatility. The theory of peak oil was proposed by a scientist named Marion King Hubbert in the 1950s and has since been called Hubbert's Curve. Hubbert maintained that the domestic oil reserves of the US would peak first, followed by a decline in worldwide production.[1]

Despite the well publicized findings of Hubbert, the world economy is not ready to adapt its agricultural practices, military capabilities, vast computer networks, and modes of transportation to function completely without oil. Further industrialization of states will only increase demand for oil and tighten the link between the security of states and their ability to ensure reliable access to oil. To withdraw from dependence on this essential ingredient is equivalent to entering an oil rehab, and few governments are willing to check into a facility to overcome their addiction. Industrial nations like the US continually to announce their motivation to end their oil addiction. Despite elaborate speeches to this effect, the reality different.

The illusion of cheap energy is not, however, the most pressing issue. It is climate change. There is overwhelming evidence that human activities, such as the burning of fossil fuel emissions, are contributing to global warming resulting in long term climate change. The institutionalization of researching climate change, most notably the United Nations Framework Convention on Climate Change (UNFCCC), holds annual conferences to examine short and long term methods to counteract global warming. These committees continually urge the world's

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[1] The Hubbert Tribute. *The Hubbert Tribute*, THT, 28 Feb. 2006. Web. 3 Mar. 2011. <http://www.mkinghubbert.com/about/tribute>

largest economies to lower their CO2 emissions. The problem is, all too often, that the politics are greatly influenced by a 'business as usual' philosophy. Rapid growth, every country's objective, requires access to cheap energy (mainly oil) and the response of states has been twofold: to increase domestic production (where possible) or to increase and diversify external sources of supply. The short-term economic goals enabled by oil prevail over the long-term goal of arresting climate change by investing substantially in new forms of energy.

Climate change, together with the challenge of peak oil, is among the major problems facing the world today. The challenge for all nations is how to combine growth with sustainability. The dilemma in its simplest form is the following. On the one hand, states must compete with on another to secure oil access and sustain their infrastructural networks and economic growth targets; on the other hand states are pressured to participate in the global agenda of minimizing the impact of climate change, by limiting fossil fuel use. These economic and political debates are reflected in public policy discussions in both developed and developing countries; but the results have not been encouraging.

Nations with the potential to be oil-exporting economies are quickly put on the global grid, because of demands by consumer giants like the US and China, and this often happens even before any oil is sold on the market. Two examples are the first Russian pipeline to Asia, and Brazil's off shore oil drilling projects, which are estimated to have the largest underwater reserves in the world. Peak Oil and the long term effects of climate change simply have not been sufficient to convince states to reconsider stronger resistance to oil as their primary energy source. Instead, states (for example the US) are investing heavily in foreign oil developments, while investing only minimally in the R&D (research and development) needed to develop

reliable and competitive clean energy sources with the relevant technologies to produce and distribute them so as to supplant the dependence on oil.

If one compares the United States, still the most powerful state in the world and the one with the most dynamic economy, with China, still in many respects a poor country, it is the latter, surprisingly, that has the better record when it comes to efforts at developing clean energy. Clean or alternative energy R&D investments are critical to finding solutions towards lowering state CO2 emissions, while simultaneously easing dependency on oil. While large scale industries and transport require massive amounts of energy provided by oil, local projects and every day use of electricity have proven effective when using alternative energy technologies.

During the UNFCCC conferences, developed nations are presented with statistical analysis of their higher carbon emissions when compared to the more populous developing states. The United States is by far the leading polluter and is under international pressure to lower its carbon emissions. The Peoples Republic of China is the second largest emitter and is likewise being pressed to reduce its emissions. China has taken the first step towards a clean energy market by aggressively subsidizing the R&D needed to make clean energy more efficient. The US on the other hand is falling far behind. China has also taken steps towards integrating alternative energy in its infrastructure, and can be seen with its so called efficiency-seeking developmental zones.

Despite its efforts to develop and export renewable technologies, China faces an uphill battle given the extent to which it relies on both oil and coal. Like the United States, China must ensure its cheap energy access is sufficient to provide for its growing population and future development goals. Its officials can only maintain power by ensuring high growth rates.

China's advantages include a large work force and a growing annual GDP (gross domestic product) of 9-10% since the late 1970s. It also has the advantage of pursuing growth in an era when technological breakthroughs have made non-oil sources of energy feasible. The US experienced its industrial revolution during a time of abundant and inexpensive oil. By contrast, China is developing during a time when alternative options for energy are available and the discovery of human induced climate change requires a disciplined fossil fuel consumption. China's Authoritarian Capitalism maintains control of its domestic industries, and imposes carbon reducing laws at will. It is this type of economic mobilization that the US is lacking in its energy sector. The international community is waiting for the US to become the leader in developing clean energy. The rest of the world however, must also do its bit as America's share of global economic output is declining and it cannot solve the problem of combining growth and sustainability alone.

II. Research Design & Methodology.

In this thesis I will examine the linkage between the oil industry and the clean energy industry. After the introductory chapter there are two others: one focuses entirely on oil, the other on clean energy. While the use of coal started the industrial revolution of the eighteenth century, this thesis focuses on oil, which is the fuel that powers the current global economy.

The US has enjoyed its hegemonic status due to years of access to cheap oil, which has increased its industrial and military might. The question now is, whether the US can translate its economic and technological prowess to lead the way to a clean energy revolution. So far it

seems not. The world's sole superpower has failed to ratify the CO2 reductions guidelines of the Kyoto Protocol and its achievements in producing clean energy fall short of its great potential. This thesis therefore examines the political obstacles that are inhibiting the US power from doing what is necessary to slow both climate change and the world's oil addiction.

It is critical to consider the challenges the US must overcome in funding and implementing clean energy breakthroughs if less developed societies are expected to do the same. When considering CO2 emissions, China has taken the lead from the US as the world's largest emitter and within only a decade. The world watched as China grew to its current status as a major economic and political influence. With a GDP that has now surpassed Japan it is no surprise that China is becoming a powerhouse nation. China has acknowledged its growing emissions problem since the failures of the Kyoto protocol and its low expectations of the developing-nation category. China has since then taken greater steps in clean energy investment to degrees that have put even the US to shame.

This thesis will use China to demonstrate the domino effect of one nation's competitive drive in exporting clean energy products and how China's success could spur the development of clean energy worldwide. The US and China can also be studied to compare the pros and cons of two different regime types, when it comes to implementing clean energy solutions..

In Chapter 2, I will provide a historical summary of the challenges faced within the first decade of oil production in America and later compare these to the current challenges faced with the clean energy industry. I will also discuss the history of the peak oil theory starting with the Hubbert's Curve hypothesis that US domestic oil production would peak in the 1970s, giving its later world-peak-prediction legitimacy. With this I will examine current world reserves and

explore whether they are being depleted faster than new deposits are being discovered. By looking at current global market signals I will conclude that we are most likely witnessing the very first indications of oil peak based on extraction with conventional methods. A combination of factors validate the global peak oil theory: the reluctance of Saudi Arabia to disclose output numbers and quiet the skeptics, the increased volatility of an oil market the seems incapable of increasing supplies enough to satisfy demands, the reports of water injection methods increasingly used to stimulate production in aging oil fields, and the increasing global trend toward investing in offshore oil production. All of these conditions point to conventional oil fields being depleted. I will also demonstrate how the oil industry really isn't as inexpensive and simple as many believe. I will do this by looking at the advanced oil production of Saudi Arabia.

I will then shift in Chapter 2 from oil theory to oil politics. I will provide background of the trade relationship between the US and China and reveal energy competition between the two. I will then compare the oil investments of the US and China to demonstrate their foreign and domestic strategies towards oil production. I will show how implementing risk-reduction policies (policies that reduce dependency one source alone) and diversifying foreign oil supplies are becoming more critical in times of declining reserve output. I argue that the US and China will continue to invest in the oil industry instead of abandoning it and moving forward with clean energy. Even as China invests in its clean energy technology, the competition for fossil fuels puts pressure on China to secure and diversify its access while it can still be produced efficiently.

Chapter 3 will be devoted to alternative-energy technology. I will briefly discuss the subject of climate change advocating more competitive clean energy investments on a global

scale. While various alternative energy sources will be examined, this thesis will conclude that the solar power and electric car industry are the most efficient and useful for transitioning countries' infrastructure away from fossil fuels. By looking at the pros and cons of the various clean energy systems, I will show how their market inefficiency a product of the lack of adequate funding and not mere technological limitations. I will also answer the widely debated question as to why the US can't keep up with a developing nation (China) and its clean energy investments. This question will be answered by examining the strengths and weaknesses of the liberal democracy of the US and the advantages that China may have by virtue of its authoritarian polity. While China is dealing with the negative effects of rapid economic growth, US alternative energy policy has in the past been disappointing, and one reason may be that the American political system is incapable of organizing political consensus.

This chapter will also discuss the US-China trade relations concerning clean energy and the protectionist tendencies of China's industries. My conclusion for this chapter will examine the political steps needed to enable clean energy technology to flourish. Considering that the US and China have the largest GDPs in the world, this thesis will examine the political and fiscal policies with promoting R&D for alternative energy compared to that of fossil fuels.

Chapter 4 will conclude the thesis. It will reinforce the need of the US and China to take the lead in clean energy and help clean energy technology progression as a competitive, commercial market. This chapter will also incorporate a variety of political theory to demonstrate how the clean energy market has affected the relationship between states. These will be used to explain the behaviors both China and the US feel are necessary to secure their energy needs.

Literature Review.

This thesis will use a combination of primary and secondary sources including books, official web pages, government documents, and scholarly journals. Various political science theories are useful for understanding conflicting state behaviors spurred from their domestic needs adjusting to global market pressures, and their relative utility depends on what question is being explored. The theories relied upon in this thesis includes neorealism, neomercantilism, prisoners dilemma, and collective action problem. International Relations Theory by Kenneth Waltz will be referenced extensively given that he is the pivotal figure in of neorealism. Robert Gilpin's Global Political Economy: Understanding the International Economic Order will be used because it combines realism with neomercantilism, the latter being particularly useful to understand the economic bases of states' strategic competition.

"Game Theory" has a large literature, but for purposes of this thesis, Robert Axelrod's The evolution of cooperation has been useful along with After hegemony: cooperation and discord in the world political economy by Robert Keohane. This is because of the insights these readings offers from liberal theories of international relations. When it comes to the energy market, both competitive and cooperative behaviors are seen between nations and these will be discussed in detail in the concluding chapter.

One of the most useful books written on the oil industry and market is Twilight in The Desert by Matthew R. Simmons, former energy advisor to U.S. president George W. Bush and member of the National Petroleum Council. It accepts the global oil peak theory, and emphasizes the need for greater transparency with the aging Saudi Arabian oil fields that supply much of the

world's oil. I will refer to the official webpage of the organization Simmons & Company International.

The works of the highly recognized energy expert Daniel Yergin will also be an essential source throughout the thesis. Yergin has investigated oil supplies and politics in the Middle East and the emergence of a liquid gas market. In such works as The Prize, he provides a history of oil politics of the US and the oil industry in the Middle East. I will also rely on Yergin's other publications, which stress the peak oil problem and the need to develop alternative energy sources.

Primary sources for statistical data include online official sites such as the, The International Energy Agency (UNFCCC), The New York Stock Exchange (NYSE), and various oil and clean energy industry websites from both US and Chinese companies. Various online journal sources will be used as well to provide greater perspective on the world developments with the clean energy sector. Clean energy technology will also be researched using web based industry sites.

Chapter 2. Oil

History of The Oil Industry.

Society's long relationship with oil is one that resembles a dramatic love affair, or soap opera. The marriage of society to oil began with feelings of infinite optimism blinded by the many benefits of using oil. These feelings then quickly turned to a self-destructive addiction. Finally, this addiction has resulted in the overall denial of oil's environmental ill effects and its finite availability. Society now flirts with the prospects of clean energy, but it is still far from divorcing itself from oil and that is because the alternatives are still relatively expensive.

This section introduces oil's debut, starting with its discovery in the US revealing that oil was far from cheap and efficient. The oil industry was founded by the determination of a handful of individuals willing to go against the majority, being pessimistic towards oil. This is critical to discredit arguments against alternative energy based on the technology not being worth its current expense and market risks. The focus will be solely on the US oil industry. This is mainly due to the extensive documentation of oil's earliest struggles within the US market.

The US pioneered the oil industry and its commercial sales beginning in the 1800s. With the first oil wells of northern Pennsylvania, the US created a method for oil extraction that spread like wildfire across the oil bearing states. The first simple (low capacity) oil wells were used in the mountains of Titusville Pennsylvania. Oil first made its way to the surface when wells designed to extract ground water would accidentally bring up oil clumps, initially considered a nuisance or waste to be disregarded. With growing curiosity of this abundance of black substance

coming out of the earth, oil was initially experimented on as a lubricant for machinery. Oil was then put to greater use to illuminate lamps, which previously depended on whale oil. This set the stage for the oil market as entrepreneurs began to seek profits from refining oil and selling it as an illuminate. The abundance of the oil seep in Titusville led to the first American oil wells along with its many unexpected production challenges.

In 1853 Joel D. Angier from Titusville leased the local oil seep, transacting the first petroleum lease in the United States, however oil was not collected in sufficient amounts to make the operation economic enough for Angier to continue.[2] Another Pennsylvanian Hamilton McClintock, exploited areas south of Titusville, producing up to thirty barrels a season.[3] The success attracted entrepreneurs from New York being both daring and determined, these New Yorkers set off to expand the market for oil. Any theories of its large scale excavation and production however, was not yet put to practice.

It all started with a New York lawyer named George Bissell and his partner Jonathan Eveleth. After Samuel Martin Kier's discovery that crude oil could be used in lamps, oil was becoming something of great value. Bissell put together a crew including leading Chemist Benjamin Silliman, Jr. of Yale, to study oil to attract New York investors. However, the limited knowledge of crude oil led to serious set backs in its big city debut, including spills during transport and pesky leaks within sealed barrels. The worst was with Silliman's failed lab assignments aimed at demonstrating oil's versatility. As Pees puts it,"His retort and other devices blew up during analysis and the team had to pay for research after failed fund raising efforts in

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[2] Pees, T. Samuel. "Oil History: Oil Creek Before Drake's Well." *Petroleumhistory.* Samuel T. Pees, 2004. Web. 28 Feb. 2011. <http://www.petroleumhistory.org/OilHistory/pages/drake/beforedrake.html>

[3] Ibid.

New York ... it is a wonder that oil ever got to market from Titusville with all these early omissions and pinching of banknotes."[4]

The preliminary drafting of the first oil company and the challenges it faced are somewhat comical to read about. This story demonstrates Bissell and Eveleth's perseverance with oil production. The mysterious substance was far from cooperative with even simple tasks such as moving and storing it in mediocre amounts posing huge challenges. It is ironic that the modern characteristics of oil being easy to store and transport were initially difficult to achieve. Pees details this chapter of oil's production history as follows:

> While stock companies and other oil matters were being formulated in New York, the crude didn't cooperate as fully as the promoters and businessmen wished...A shipment from Titusville of three barrels for demonstration purposes arrived in New York City in 1854 and was deposited on the street in front of the very elegant and new building of D. Appleton and Company where art works, fine books, and other fancy treasures were sold. The offices of Eveleth and Bissell, lawyers and oil promoters, were upstairs. Those...that had never scented raw petroleum, declared "whatever it was" to be vile, and veered away from the Appleton Building. Not picked up immediately and "cooking" in the sun, the leaky oil barrels were finally taken away from this princely spot. Strangely, this happened before the promoters were aware of the oil's presence...even the paving stones (Broadway) on which the barrels stood were dug up and replaced by the bookstore. When Eveleth and Bissell learned that their oil had arrived but had been hauled away by a junk man, they went on a mad search to find it. These three barrels were to be the basis of chemical experimentation and promotion. It took several weeks to find the barrels. Enough oil remained to fiddle with. However, the oil was still to be a problem. They took a portion of it to their upstairs office (probably in stealth) where it accidentally was spilled and oozed into the floor, even marking the ceiling below. Plans to form an oil company appropriately took place in this office with its oily floor. It seems to me, that Appleton and Co. should have a place in the history of oil, their magnificent building of that time being the site of an early spill (1854) of Pennsylvania crude oil in New York City, and it was the site of the preliminary drafting of plans for the first oil company.[5]

The Pennsylvania Rock Oil Company was America's very first oil organization (later known as Seneca Oil). The small Seneca company was still run by Bissell and Eveleth and begun its operations in Titusville.

Edwin L. Drake is another important figure in the history of oil production. The tapping of the first oil well ever to be made occured under his watch, and his name carries on in history

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[4] Ibid. "Chemical Report Of Seep Oil"

[5] Ibid. "Pinched Noses"

with the naming of Drake's Well. The Seneca Oil founders had crossed paths with Drake on their trip to Titusville. Drake was intrigued by the new oil market and had bought stocks in the Seneca company. As a railroad conductor Drake traveled free of charge, and was on his way to visit the Titusville site himself. This was enough incentive for Seneca to hire Drake full-time. The Seneca executives were in need of someone to travel to the seep area in Titusville and provide reports on its production. Drake's first assignment was to reopen the original wells attempted by Angier and to improve their extraction output rate. After many failed attempts and experimentation with drilling methods, Drake finally got lucky. In August 1859 the drill finally hit oil going at a relatively short depth of 69 feet, to be later known as the famous Drake's Well.

Drake was hardly an experienced business professional. He never thought to patent his unique drill design that created the first extracting mechanism for oil. In turn, others copied both his drill design and drilling method, leading to further improvements and the creation of the earliest American oil industry. While Drake may not have had the corporate experience of Bissell and Eveleth, his perseverance in creating the first working oil well in the small town of Titusville started an energy revolution that even Drake himself could not have imagined.

As earlier as 1865 the emerging oil business made its way to California Central Valley, where the Union Matolle Company drilled the first productive wells becoming the scene of drilling activity in the 1800s.[6] The largest wells in California were still yet to be discovered. In 1892 two men, Edward L. Doheny and his mining partner Charles A. Canfield originally set out for mining gold, switched their business motives to oil and discovered the largest oil field in California.

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[6] "The Story of Oil in California." *Priweb.* Paleontological Research Institution, n.d. Web. 1 Mar. 2011.

Doheny and Canfield began their quest for oil after noticing tar on the wheels of carts in downtown Los Angeles, shortly examining the area ... leading to the discovery of the Los Angeles oil field after drilling 140 meters.[7] Within two years the number of wells in downtown Los Angeles was almost up to 100 and after five years expanded to 500, making Doheny and Canfield America's first oil millionaires. Most of American oil drilling was now being done in California State.

While the oil well was invented in Pennsylvania, America's greatest oil production capacity was in Texas. In the late 1800s Texas had its own oil wells but these only produced moderate amounts of oil barrels a day compared to California. Oil men from Pennsylvania came to invest in eastern Texas "Oil Springs" of Nacogdoches in 1888. These investors produced higher rates of output at about 250-300 barrels per day, attracting other oil companies to the area to expand.[8] Texas was quickly becoming the place to invest in oil. As wells were already crowding California territory, investors were seeking untapped reservoirs.

The oil industry produced marginal profits and was still very expensive, requiring constant maintenance of the oil derricks. Patillo Higgins believed that oil would eventually replace coal despite the many challenges with its production. All that was needed was for there to be enough oil production to replace the market for coal. This was later achieved in Beaumont Texas. An engineer and salt miner named Anthony F. Lucas got word of Higgins predictions and experimented with drilling at the famous "Spindletop" salt dome of Beaumont.

Drilling was especially difficult at Spindletop, which lead to the revolutionary solution of using mud instead of water in the drilling process, and on January 10, 1901, oil was extracted for

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[7] Ibid.

[8] Ibid. "Spindletop, Texas."

the first time in record amounts after gushing into the air at one hundred and fifty feet.[9] This was by far the most oil that had ever been extracted; nearly one hundred thousand barrels a day, more than the output of all the oil wells in America at the time.[10]

While the oil business became increasingly popular thanks to the Spindletop gusher story, the industry still could not overcome its inefficiencies. Even with the seemingly endless amounts of oil being extracted at Spindletop, the millions being made did not exceed the millions in production costs. Investments however increased and so did oil drilling. More investments meant devoted research on oil and its production. With the explosion of oil derricks covering fields in both California and Texas, once such reserves were proven abundant it wasn't long till oil was experimented on for use to power engines. The invention of the internal combustion engine was the greatest catalyst for further oil production and its ability to surpass coal.

The discovery of both large underground oil deposits and better drilling methods led the oil industry to produce greater amounts of oil, but with no real holding and transporting facilities. By increasing extraction the oil industry ultimately faced a surplus problem. The surplus of oil resulted from the lack of proper transport and storage. The old wooden-barrel storage technique constantly resulted in leaks and spills. Oil boils and expands in heat, and has a high salt-water content often melting right through the adhesives used to seal the wooden barrels. Pressure would often build up and explode as oil barrels sat in the heat of summer. It was unknown at the time that oil had a significantly lower boiling point compared to the original illuminants used.

Traditional methods of transporting products by flatboats and wagons were not well suited for oil either, and couldn't keep up with the increasing supplies of oil. Oil was heavy to

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[9] Ibid. "More About the History of Spindletop, Texas."

[10] Ibid

haul on wagons and transportation by boat was limited to the availability of rivers. There needed to be an efficient means to transport oil great distances if it were to continue being sold with credibility on the market.

The use of railroad cars soon became popular for moving large amounts of oil, but storage barrels continued to leak and topple over despite attempted design improvements. These challenges eventually led to the invention of durable large-metal-tank carriers. The industry however, still had its skeptics even with such high levels of investments in producing and transporting oil across states. Oil was debated to be a temporary obsession.

The horizontal metal tank carrier was first proposed by Evans W. Shippen, who built a scale model for railroad officials. The Pennsylvania railroads were already hauling large amounts of oil, yet their officials saw the tank proposal as unnecessary stating that 'by the time a car could be completed there will not be sufficient oil produced to fill it.'[11] Shippen disagreed with this outlook on oil supply, but still could not convince the railroad officials of the need to invest in producing metal tank cars.

After failed attempts to increase car capacity with large wooden barrels and box cars, the horizontal metal tanks proved to be the only solution left. Railroad officials finally began to feel the overwhelming loses with traditional wooden box car methods, as oil supplies were far from running out. The details of the first metal tank cars are described below by Pees.

> In 1868 the boiler-type tank car was made and tried out, had the requisite low center of gravity, and a dome shape which permitted the oil to expand (a function of temperature) without damaging the sealed horizontal container. The Empire Line, a fast freight subsidiary of the Pennsylvania Railroad, quickly adopted the boiler-type tank car and put it into use in February, 1869 (Giddens, 1938). These horizontal iron tank cars had capacities of 80-90 barrels at first and then 100 barrels during the late 1870's. The wooden Densmore tank cars gradually disappeared in the 1870's, as

[11] Ibid. "Early Failed Attempts."

had the wooden oil barrels before them whose days were numbered when pipes began to carry oil in 1865.[12]

The metal oil tank allowed for a more efficient way transporting oil securely using railroads. The oil skeptics were proven wrong as the industry continued to grow in supply and demand, and created a new profitable division for the railroad companies.

The next revolutionary transport system for oil was the oil pipeline. Like all former steps in the oil industry the development of the first oil pipelines in the early 1860s failed due to the limited technology available. The idea for the pipeline came about when oil fields were discovered in areas that were both too far from water sources to be carried by flatboats, and deep in forests too dense for wagon transport. The first pipelines were created by using the forces of gravity to carry oil from wells to cities. The first pipeline idea was supposed to carry oil 36 miles from a well near the Ohio River. This proposal by the young Samuel D. Karns was interrupted in 1861 with the start of the Civil War; however another pipeline was proposed by Heman Janes and was built at Tarr Farm Pennsylvania Oil Creek in1862.[13] It didn't take long for the oil pipeline to become an essential part of the oil industry.

The development of oil pipelines evolved through several stages. The traditional gravity based wooden structures switched to experimental cast-iron pipes with powerful pumping mechanisms. While the earliest pumps failed miserably, the pipeline projects continued with the combination of more powerful steam pumps and human perseverance. The creation of the first successful oil pipeline resulted in lines being heavily used in Pennsylvania throughout the 1860s.

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[12] Pees, T. Samuel. "Oil History: Metal Tank Cars." *Oil History.* Petroleumhistory, 2004. Web. 28 Feb. 2011. <http://www.petroleumhistory.org/OilHistory/pages/Barrels/observations.html>

[13] Ibid. "An Oil Pipeline Proposal."

The first American pipeline company operated from 1867 to 1871, and was valued at $2 million and covered 500 miles of Northwest Pennsylvania, connecting oil fields to railroad terminals.[14]

With the invention of more efficient oil transport and storage systems, the oil revolution attracted increasing investments, giving birth to a million dollar American industry. Oil production was only greeted with optimism when the extraction and transportation methods evolved to a point of efficiency. By correcting the oil storage and transportation weaknesses, the oil surplus could be transformed from a problem to a profit. Large amounts of oil were now available to be transported further distances without the worry of losing oil supplies. This allowed for the oil market to extend its reach to other cities far from the location of its wells.

The success of the oil industry came from the optimistic push forward by a handful of individuals reluctant to give up on its market potential. From the early exploration of oil in the 1850s to the exponential growth of its transportation industry in the 1870s, oil pioneers overcame the limits of knowledge with the first production of oil wells. Traditional means of ground-well production with the more common (and cooperative) resources did not suffice with oil. The industry needed the financial support in order for ideas to be tested, and for any failed projects to be resurrected and made successful.

These struggles with oil demonstrates how our current perceptions of the challenges with the clean energy industry are not unique. Oil was not easy to collect, store, and transport; nor was it easily financed under these highly unfavored conditions. While technology has greatly improved since the 1800s, a high-tech society does not eliminate the processes of going from

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[14] Ibid. “First Great Pipeline Company.”

initial discovery and experimentation, to maximum utility of a resource. Innovative ideas that seem unlikely can turn successful and produce an industry that could change a nation.

III. Peak Oil Theory, Then and Now.

This section will be begin with the origins of the peak oil theory by M. King Hubbert. The theory began with the domestic prediction of US oil supplies running out in the 1970s. The theory was then put to use on a global scale with the world's conventional oil supplies. This thesis will use the global peak oil theory to show how the it has created a sense of urgency to invest in alternative methods of energy before its too late. I will also go over the difficulties with unconventional oil production sources such as off shore, oil sands, and oil shale. I will then focus on one oil-rich nation to investigate its oil production peak and to demonstrate the hardship even the conventional oil industry faces. There are no larger oil fields in production than those of Saudi Arabia, and these will be my focus. Here lies the world's largest land reserves constantly under close watch for evidence of peak conditions, as its production numbers are closely guarded by the Saudi royal family.

Peak Oil Theory predicts when the maximum rate of oil production will be reached, since oil reservoirs hold limited amounts of more easily extractable oil. This maximum production rate is calculated by looking at the rate of production at current "proven" reserves (often overstated due to lack of transparency with oil officials) and the rate of discovery of new ones. The oil peak theory was pioneered by scientist M. King Hubbert who noticed that crude-oil discoveries in America followed a bell-shaped curve as did production with each individual well. During the

debut of Hubbert's oil peak theory in the 1950's, the self sufficient US and its oil industry used land based crude from its lower 48 states. It was assumed during Hubbert's days of research that American oil reserves were far from limited especially since the US was the world leader in oil production.

Hubbert was one of the most accomplished scientists of his time. His memorial states "there was not a geologist, hydrologist, geophysicist, petroleum engineer, or mineral economist in the entire world that was not deeply in his debt."[15] Hubbert's major contribution to science included his application of physics to geological process resolving a standing paradox of the strength and flexibility of materials in the earth's crust.[16] He also made breakthrough discoveries on the flow of underground fluids, leading to major advancements of techniques for locating both oil and natural gas deposits.[17] In other words, Hubbert was a greatly respected scientist. However, when his research on American oil supplies led him to the peak theory, his findings were unappreciated and went unsupported.

Hubbert worked for Shell Oil between 1943 and 1964, helping advance America's understanding of crude oil during the heyday of US oil domestic production. In 1956 Hubbert made his findings on American oil supply public in a speech to the American Petroleum Institute. It was with this bold speech that faced heavy criticisms. Officials did not dare support a theory predicting the near end of America's oil production. Hubbert's 1956 speech proposed that the American oil production would peak in the 1970s and that government officials needed to begin

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[15] The Hubbert Tribute. *The Hubbert Tribute*, THT, 28 Feb. 2006. Web. 3 Mar. 2011. <http://www.mkinghubbert.com/about/tribute>

[16] G. Unger Vetlesen Foundation. *The Vetlesen Prize,* LDEO, n.d. Web. 3 Mar. 2011 <http://www.ldeo.columbia.edu/vetlesen/recipients/1981/hubbert_bio.html>

[17] Ibid.

considering its consequences. The peak theory and its revelations were graphed by Hubbert with a bell-shaped curve diagram later to be known as Hubbert's Curve. During his speech to the Petroleum Institute, Hubbert's Curve was discredited by oil officials as inaccurate and was ignored by the government officials who had initially asked Hubbert to conduct such research on the oil supplies of the Lower 48 states.

The controversy surrounding Hubbert's Curve and his predictions were later proven correct when US oil production did peak as predicted in the 1970s. This was the turning point of the maximum production rate for the entire nation and more importantly the end of self sufficiency. The unfortunate part of oil peak theory is that its predictions can only be verified after the actual peak has occurred, and not a moment sooner. In other words, a nation will only realize that is has reached oil peak when it is in its first stages of oil decline. This decline begins when oil production in incapable of keeping up with previous levels as it heads down a steady slope to depletion. Only once a nation's production rate remains steadily below what it used to be will the industry being to realize its reservoirs limits, and begin to adapt to peak conditions. This adaptation involves turning to more difficult unconventional methods of oil production such off shore oil exploration, as well as scouting for oil access abroad.

It is essential to understand that oil peak occurs when the extraction of oil has reached a point where the methods (or technology) being used are no longer efficient in production. What this means is that as oil reserves age the oil becomes more difficult to extract since the easiest oil supplies in the reservoir are consumed first. The higher quality oil known in the industry as sweet-crude is extracted first, leaving the oil of less quality of heavier sour-crude left in abundance. Having a much higher sulfur content the heavier sour-crude is far more expensive to

extract and refine. Oil prices are largely based upon the availability of the quality of oil and rises significantly if the sweet-crude is no longer in abundance within a major exporting reservoir.

It is critical for society to investigate the world's overall oil supplies considering the years of research on peak information available. The proven accuracy of Hubbert's Curve in the American context raises the question of whether this method of calculations can be applied in predicting the end of world supplies. Hubbert took this initiative and applied his curve diagram to the world oil production and discovery rates and presented his world peak theory in 1976. When he applied his peak calculations to global parameters he came to the conclusion that the world oil peak will be around the year 1995 and that eighty percent of the world's oil will be used within a span of only 56 years, from the late 60s to the year 2020.[18]

While there is no consensus on the actual year of world oil peak, research has placed global oil to peak between the years 2006 and 2020. Supporters of the peak theory can be divided into two groups. There are those who believe the world has already reached oil peak in the past ten years, and then there are those who believe the world is likely to reach oil peak in about ten to fifteen years. Neither scenario encourages the continuity of heavy investments in the oil industry. As the abundance of sweet-crude oil becomes a thing of the past, the high cost low-quality oil that remains will make turn a cheap energy industry into a losing business.

Many individuals and organizations have supported the pressing need to research global oil supplies. These include oil geologist C. J. Campbell, and former White House energy advisor Matthew R. Simmons, and the World Energy Council, which has conducted extensive research and provides various publications on world oil peak theory. A significant point in acknowledging

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[18] M. King Hubbert. Interview by John Robins. *Health Facilities and the Energy Crisis: A Conversation with M. King Hubbert.* American Hospital Association. WETA-TV, Chicago, 1976. CollectiveLiberation.com. Web. 26 Mar. 2011. <http://collectiveliberation.com/2011/02/04/vintage-oil-crisis-film/>

of the peak theory was reached when the official world energy agency The International Energy Agency (IEA) for the first time included peak developments in its *World Energy Outlook* (WEO) 2010 projections.

In 2005 one of the most detailed reports of world oil peak was written by Robert L. Hirsch at request of the White House. At the time Hirsch was a senior energy advisor for the Fortune 500 company SAIC (Science Application International Corporation) and had an extensive professional background in leading energy and technology research.[19] This report entitled *Peaking of World Oil Production: Impacts, Mitigation, & Risk Management,* examines the consequences of premature mitigation and late mitigation when it comes to peak oil. This report does not stress the importance of knowing when peak oil will arrive. The Hirsch document states that, " prediction of the peaking is extremely difficult because of geological complexities, measurement problems, pricing variations, demand elasticity, and political influences."[20]

The report provides extensive research on the consequences of peak oil and concludes that the most oil consuming industry in most economies is transportation, and will be most difficult to replace the needed liquid fuel. In short, Hirsch argues that what appears to be an energy problem is really one of finding replacements for today's cheap liquid fuels. This argument is also important to consider when looking at climate change mitigation efforts. While there exists substantial clean technology, options to feed an electrical grid, clean transportation methods (replacing fuel) are few and so far only work with land based vehicles.

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[19] NSTI Nanotech. *Nano Science and Technology Institute*. NSTI. 2008. Web. 25 Mar. 2011 <http://www.nsti.org/Nanotech2008/showbio.html?id=113

[20] Hirsch, Robert, Roger Bezdek, and Robert Wendling. "Peaking of World Oil Production: Impacts, Mitigation, & Risk Management." *The National Energy Technology Laboratory.* USDOE. Web. 25 Mar. 2011 <http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf>

Complicated exogenous variables have been brought into the argument to calculate the peak of oil at a global scale. These variables can sway the public opinion of peak oil and should be looked at in detail to determine if they support or go against the theory. These exogenous factors are as follows: record high levels of demand for energy from upcoming nation's on the world's oil supplies; the addition of new unconventional methods of extraction being used to counterbalance the overwhelming increases in demand.

These exogenous factors affect modern thinking of oil peak theory in the following ways:

I. The first supports global oil peak theory and the limits with current supplies, as significant increases in global energy demands puts more pressure on the worlds leading oil exporters, the rate of production increases and speeds up the peak process. It is no surprise that large scale economies, such as the US and China, outsource oil contracts as a risk-reduction policy. As emerging economies demand more energy from oil exporting states, as soon as supplies struggle to keep up the theory of oil peak gains greater relevance.

II. The second factor is the argument that calculations of oil peak are often exaggerated and exclude the potential of unconventional oil production replacing the stressed conventional land sources. This argument does not appear to be valid. It assumes that conventional oil peaking will not effect global oil peak as the unconventional methods as readily available to continue cheap fossil fuel availability. Unconventional methods of oil production can be split into two categories, offshore oil exploration and unconventional land sources. Neither form of oil has provided the world with a significant supply at the rate of production efficiency that

can compete with the traditional land wells. All other options continue to face ambiguity in their high-quality oil production capabilities limiting its desired inclusion in the oil market.

To demonstrate the difficulties with unconventional oil production methods I will briefly go over some of the more prized breakthrough methods in the oil industry, including deep sea oil exploration and some of the difficult land oil deposits including, "oil sands" and "oil shale." I will begin with offshore production and then move to the two unconventional land sources. These are important to evaluate since they are believed to have the potential to replace conventional oil, and for this reason they create competition with clean energy for government and public support.

Offshore oil exploration has been a part of the oil industry since its earliest production in the 1800s. Only until recent breakthroughs with deepwater exploration has off shore oil drilling been attracting investors and gaining developmental contracts all over the world. The offshore oil industry potential had been mislead by both media and oil officials in its claims that the industry is capable of bringing energy independence.

The worldwide offshore rig market now suffers from oversupply as new rig deliveries exceed demands, causing old rigs to lose their long term contracts.[21] The US oil industry seems to be selling smoke to gain contracts from the Mineral Management Service (MMS), as contracts are being granted but the oil being produced is noncompetitive in the global market. Premature hopes with the offshore oil production making the US energy independent is "nonsense," according to Robert Kaufman an expert on world oil markets and director of Boston University's

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[21] Donovan, Matthew. "Reviewing The World Offshore Rig Market." *Offshore Magazine.* Pennwell Corp. 1 Feb. 2011. Web. 25 Mar. 2011. <http://www.offshore-mag.com/index/article-display.articles.offshore.volume-71.issue-2.rig-market-review.reviewing-the-world-offshore-rig-market.QP129867.dcmp=rss.page=1.html>

Center for Energy and Environmental Studies.[22] The US consumes 20 million barrels of oil a day while it only produces about 5 million daily, requiring the US offshore oil industry to fill a 15 million-barrel gap.[23] Until greater advancements the offshore drilling industry lacks necessary efficiency and reliability to compete in the global oil market.

The current production capabilities with unconventional land sources of oil face even greater challenges than those of offshore oil drilling. These land sources are also known in the industry as "heavy crude oil" and until now has lacked the technology for its extraction and refinement. While large liquid crude oil deposits are abundant in the Middle East, heavy crude oil is found in large amounts in the Americas and comes in two-forms being oil sands or shale.

Canada holds the worlds largest oil sands reserves, placing it second to Saudi Arabia in proven reserves. Yet Canada still imports a large percentage of oil since the costs of producing and transporting its heavy crude cannot compete with the cost of buying liquid crude abroad. There are enough oil sands in Canada to export competitively. The Middle East still dominates the global oil market since the oil sands of Canada have yet to be fully tapped. This is because the production and refinement of oil sands requires additional steps before it can be sold as usable crude. Tar sands are so energy intensive that one barrel of oil is needed to process three barrels of the synthetic crude.[24] The process of extraction is complex requiring massive amounts of water to separate the oil bitumen from the sand.[25] CO^2 emissions also greatly increases with

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[22] Gertz, Emily. "Can Offshore Drilling Really Make the US Oil Independent? *Scientific American.* Scientific America, Inc. 12 Sep. 2008. Web. 25 Mar. 2011. <http://www.scientificamerican.com/article.cfm?id=can-offshore-drilling-make-us-independent>

[23] Ibid.

[24] Quinn, Thomas. "Turning Tar Sands Into Oil." *Energy Bulletin.net,* Post Carbon Institute, 21 Jul. 2005. Web. 25 Mar. 2011. <http://www.energybulletin.net/node/7331>

[25] Ibid.

its production and are a problem since Canada pledged to reduce emissions as a signatory of the Kyoto Protocol. These factors make investments in tar sands risky as its future market may diminish with CO2 reductions plans.

The next form of heavy crude is oil shale and is found in abundance in the United States. The American media has made claims that oil shale is the only answer to energy independence in the US. While there is enough oil shale in the Bakken formation in North Dakota and Montana to compete in the world energy market, its production faces investment delays. This is because the billions of barrels of oil that can potentially be produced from the Bakken shale would be anything but efficient. The technology involved with oil shale production is relatively new and has not yet gone beyond its R&D phase towards commercialization. According to the WorldWatch Institute, studies so far show that "oil shale extraction would adversely affect the air, water, and land around proposed projects...mining and distilling oil shale would require an estimated 2.1 to 5.2 barrels of water for each barrel of oil produced...and 100,000 barrels of shale oil would require 1,200 megawatts of power—or the equivalent of a new power plant capable of serving a city of 500,000 people."[26]

While unconventional oil sources are touted for their ability to end the Middle East's oil dominance and peak oil concerns, the reality with these forms of oil production is that they are too expensive and very risky to invest in when compared to traditional methods. The various environmental affects and high energy expense with their production leads to an overall reluctance for private investment and government support in fears of diminishing returns. The reality is that these forms of oil production do not compare with the conventional liquid high-

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[26] "Plenty of Shale, Plenty of Problems." *WorldWatch Institute*. WWN&C. 2011, Web. 25 Mar. 2011. <http://www.worldwatch.org/node/5167>

quality oil that has been fueling the world since its discovery. The entire global energy market would look very different today if just one of these methods were ever capable of competing with the conventional oil centered in the Middle East.

We have seen that the oil peak theory is widely supported and that claims of unconventional oil production coming to the rescue have even less potential than clean energy. The world will continue to revolve around the abundance of high quality oil in the Middle East. Now we can ask, what makes this type of oil production so affordable? The obvious includes the fact that it is on land and already in liquid form simplifying both the refinement and transport process. When discussing the process of conventional oil production it is useful to understand how technology has made such a complicated process economically viable. One of the best sources for understanding the long process of what the oil industry faces with even conventional oil is the international bestseller *Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy* by Matthew R. Simmons.

Simmons work is known for providing the much needed transparency on the subject of the Middle Eastern oil industry. Simmons was an advocate for peak oil and former White House energy advisor as mentioned earlier in this chapter. He founded Simmons & Company International a private investment bank specializing in energy research, trade and capital structuring.[27]

According to Simmons the first principle to grasp about oil is that "nothing about this business is simple...it is terribly complex and in many respects akin to the proverbial rocket

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[27] Simmons & Company International. *simmonsco-intl.com.* SC, n.d. Web. 26 Mar. 2011 <http://www.simmonsco-intl.com/company_history.asp>

science."[28] He supports this with a diagram that displays the detailed steps of oilfield development from the initial oil discovery all the way to its depletion and abandonment. To begin with it is both costly and time consuming to evaluate the properties of a reservoir to make sure its economical or worth the investment. After a discovery is made, it must be evaluated by estimating the amount of oil and gas in the structure and that, in turn, must be followed by a second more difficult assessment to determine what percentage of the resource can be recovered at what rate. Finally it must be determined how much of this theoretical total is economical so that it can be convincing for investors.[29]

Simmons admits that "According to many of the world's most highly qualified reservoir experts, the process of determining how much of the oil and gas in a hydrocarbon-bearing structure can be recovered easily is still constrained by our inability to fully understand the nature of the reservoir rocks, just as it was four to eight decades ago."[30] This could explain why unconventional oil sources are so difficult to advance since even traditional underground exploration is not thoroughly understood.

The world's largest proven oil field is found in the 174 mile long structure in the desert of Saudi Arabia. This structure, the Ghawar oilfield, has produced over 55 billion barrels in its lifetime, accounting for over half of Saudi Arabia's total oil production. The Ghawar reserve is closely watched by Saudi government, the owner of the Saudi Aramco oil company, as the rest of the world tries to estimate the state of production at the sixty year old oil giant. As mentioned earlier, nothing about the oil business is simple including estimating the amounts of recoverable

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[28] Simmons, Matthew. *Twilight in the Desert: The Coming Oil Saudi Oil Shock and the World Economy.* New Jersey: John Wiley & Sons, Inc. 2005. p130. Print.

[29] Ibid.

[30] Ibid. p131.

oil at a production site. According to Simmons, knowledge gained in the past fifteen years has only added to the challenges and uncertainties with operating the giant oilfield instead of providing solutions.[31]

A critical component for production at Ghawar is its water pressure support. Water from an active aquifer underneath a deposit of oil creates the pressure necessary to keep the oil trapped in place. Once drilling begins this system is slowly disrupted causing the water to begin to mix with the oil as removing the oil decreases pressures. This decrease in pressure allows gas to build up within the displaced spaces ruining the quality of the oil. As the extracted oil is mixed with water (or capped by gas pressure) it becomes more costly to pump and treat, to the point that these costs exceeds the value of the oil and the well is therefore shut down.

When early signs of decreasing pressures appear at a production well, the use of water injected systems is brought into the picture. These systems inject sea water into the reservoir in order to keep pressures high enough so that the oil can be easily extracted as close to the surface as possible. Saudi Aramco operates one of the world's most complex water injection systems to maintain adequate pressures in its large reserves. It can take up to five barrels of water to replace each barrel of oil removed from the reservoir. The intensity of the water injection system being used since the 1960s increases concerns about the life span of the multiple Saudi oilfields since these supply much of the world's oil needs. The life span of an oil reservoir is limited and can be measured by the amount of water or gas that has filled the extraction gap. If a gas cap forms or the water table rises significantly these elements will drop the pressure around the oil and will change its saturation to the point where it is no longer the useful high quality oil it was.

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[31] Ibid. p133.

Throughout the years it has been difficult to tell if the fields at Aramco sites are headed towards depletion. Aramco remains to be highly secretive of its oil production statistics. However, since Aramco is part of the Organization of Petroleum Exporting Countries (OPEC) and within OPEC plays a leading role, the Saudi government frequently reassures the public that its production has not peaked.

When wars or political uprisings result in losses in oil production, the global market price of a barrel of oil rises. When this happens the Saudi government can increase production (having the largest reserves) and lower the price of oil. However, as destabilizing events take place and the oil prices remain volatile, Saudi control over prices are called into question. These doubts create controversy over the alleged "spare capacity" of the Saudi oilfields and create suspicions that they are now less than capable of adhering to high prices and pressures of increasing global energy demands. Whenever such claims are made, the Saudi government denies them and once again reassures the world thats its oil supplies are not declining and that it maintains its spare capacity.

After the recent outbreak of violence in Libya the global market lost 1.5 million barrels of a day in exports.[32] Saudi Arabia did step in promising to ramp up its oil production and fill in this void at a rate of about one point five million barrels a day or more. This would make its total production up to nine million barrels a day to ease the world shortages from Libya. According to Goldman Sachs commodities researchers, these numbers were fixed as the spare capacity of Saudi oil is less than they would like to us to believe.[33] What this means is that instead of having

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[32] Herron, James. "Goldman Analysis Questions Saudi's Official Oil production Figures." *The Source. The Wall Street Journal*, 8 Mar. 2011. Web. 25 Mar. 2011. <http://blogs.wsj.com/source/2011/03/08/goldman-analysis-questions-saudis-official-oil-production-figures/>

[33] Ibid.

the luxury of an oil surplus to increase output at will, Goldman Sachs (and others) believe that the Saudis are giving larger output numbers than they are really capable of producing. This gives the world the illusion that they are capable of producing greater amounts of oil at will. Expensive use of the water injection systems to push more production from Saudi's aging reserves has also made stabilizing oil prices an increasingly difficult task.

These production trends indicate that the world's biggest oil reserves could potentially reach depletion within our lifetime. Despite unconventional oil production propaganda, there are no readily available alternative to replace the more predictable and efficient conventional forms. There are various individuals and respected organizations that have been actively investigating the peak oil problem by extensively researching current reserves and the physical phenomena that effect their production rates. There are also those who believe society needs to begin to examine what things would look like without cheap oil and consider how state infrastructures could potentially adapt to a world without it.

Leading oil exporters share the same burden of ensuring government transparency when it comes to their state owned oil industries. This would allow society to better prepare for the consequences of oil peak conditions. Unfortunately, this is far from how the oil business operates. Countries that specialize in oil rely on its export market for their very economic survival. If they admit to having less than abundant supplies, they risk their foreign investors going elsewhere for more reliable sources of oil.

III.Oil Politics-China vs.US.

Oil is among the world's most sought after commodities. Oil is critical for a nation to function and further develop therefore its access remains a nation's priority when it comes to its energy security. Ethanol Across America (a grassroots educational campaign for clean fuels) provides a comprehensive definition of energy security in its educational campaign stating that "Energy security is probably best understood when taken literally...we need to be secure in our energy in terms of the source, i.e. where it comes from, control of the flow and distribution of that energy, and having alternatives in place to allow us to withstand highs and lows associated with any commodity."[34]

The US has unfortunately put itself in a very difficult place when it comes to energy security. As we know most of the world's oil is produced in the Middle East, where many anti-American sentiments are abundant. The US is devoted to keeping a strong presence in this oil-rich region. Political strategies or risk-reduction policies are present to increase non-OPEC sources of oil imports in the US. However, these alternative oil industries are also peaking and nowhere near the size those proven reserves of the Middle East.

These non-OPEC oil industries, while they may have significant reserves to enter the global market, are believed to have a relatively short lifespan. According to the Institute for the Analysis of Global Security (IAGS), even as Middle Eastern supplies peak they are so ahead of the game that they will remain dominant in the market and their influence will only increase with diminishing world supplies. The IAGS website states "Russia's prospects of being a key player in the oil market in the long run are dim...ranking seventh in proven oil reserves that have peaked

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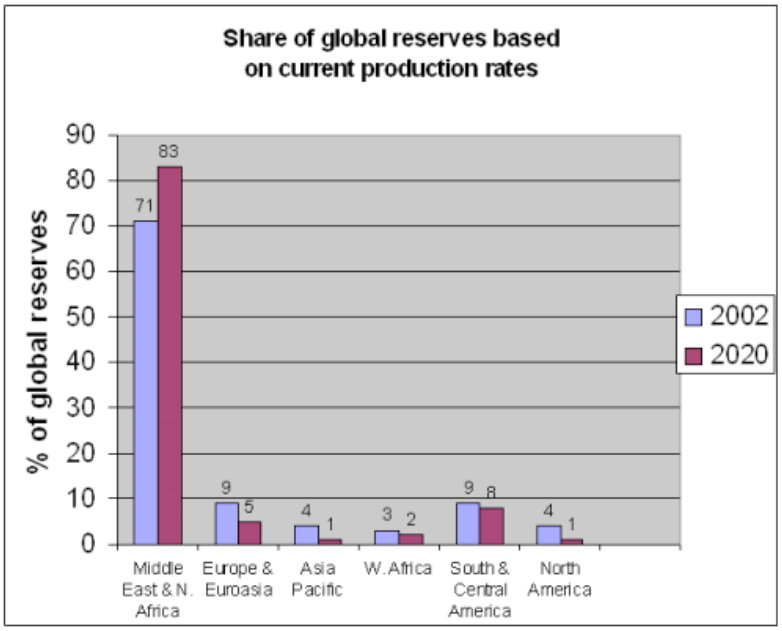
[34] Durante, Douglas and Sneller, Todd. *Issue Brief: Energy Security.* Ethanol Across America, 2005. Print. 26 Apr. 2011. Available online at <http://www.ethanol.org/pdf/contentmgmt/Issue_Brief_Energy_Security.pdf>

around 1999 and have been steadily declining since, putting Russia out of the running by 2020.[35] When it comes to the prospects with booming African oil production, the IAGS stated "like Russia, Africa is hardly a bonanza as its total reserves amount to only 7% and its largest producer, Nigeria, will peak by the end of the decade...Africa will be out of the running by 2025.[36] Figure 1 shows how the abundance of oil in the Middle East will maintain such a lead that all other developing industries will cease to be relevant players in the global market.

Figure 1. "Share of Global Reserves Based on Current Rates."[37]



[37] Institute for the Analysis of Global Security. *The Future of Oil*. IAGS. 2004. Web. 26 Apr. 2011 <http://www.iags.org/futureofoil.html>

While political tensions rise from market disruptions between oil suppliers and their buyers, competition between oil consuming states can also cause tension. This is apparent within

[35] 37 Institute for the Analysis of Global Security. The Future of Oil. IAGS. 2004. Web. 26 Apr. 2011 <http://www.iags.org/futureofoil.html>

[36] Ibid.

US and China relations as both governments are pressured to secure their oil access abroad after their domestic supply have peaked. The US has a long history of friendly economic ties to China. When it comes to its energy security, however, Sini-US relations remains uneasy. China is aggressively seeking oil supplies around the world, creating competition for the US. China's growing developmental needs along with its booming economy makes it an attractive market for oil exporting countries, especially when price is not much of an issue for China.

In 1993 China went from being a net oil exporter to a net oil importer, and by 1997 its net imports averaged 800 thousand barrels per day, twice the 1995 levels.[38] In world standards, when a country's oil imports reach 100 mbbl it should consider diplomatic, economic, and military measures to guarantee its oil supply.[39] China reached 96 mbbl in 2003 replacing Japan as the biggest oil consumer in Asia and the world second biggest oil importer, this making oil security an important driving force in China's diplomatic transformation and its military strategy.[40]

Before the 1970s oil peak the US enjoyed self sufficiency through its domestic production. During this time China's domestic oil output was high enough to export oil to neighboring nations such as Japan due to China's largest oil field (one of the largest in the world) the Daqing. The Daqing oilfield made a massive contribution to China's oil needs, accounting for an average of 75% of China's yearly production throughout the 1960's and 1970's, until it finally peaked in the 1990s.[41]

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[38]Zhang Jianxin. "Oil Security Reshapes China's Foreign Policy." The Hong Kong University of Science and Technology, *Center of China's Transnational Relations,* 2005-2006. P1. Print. 25 Mar. 2011. Available online at <http://www.marshallfoundation.org/documents/ChinaForeignPolicyEnergy.pdf>

[39] Ibid.

[40] Ibid.

[41]Xu Tang,Baosheng Zhang,Mikael Höök,Lianyong Feng. "Forecast of oil Reserves and Production in Daqing Oilfield of China." Volume 35, Issue 7, July 2010, PP3097–3102. P3. Print. 25 Mar 2010. Available online at <http://www.tsl.uu.se/uhdsg/Publications/Daqing.pdf>

The peak in global oil production raises major concerns for the US and China as both powers rely heavily on stable and predictable energy supplies to meet their economic and military needs. China is settled a lot closer to the energy rich states of the Middle East and Africa and faces far less political turmoil from the oil controlling elites. Over the years China's policy towards the Middle East has changed significantly, and Washington is a increasingly nervous about China's growing presence in the unstable region.

The Middle East now accounts for over half of China's oil imports. In a June 2004 lecture, Han Wenke, deputy director of the Energy Research Institute of China's National Development and Reform Commission, argued that China should "make full use of international influence and comprehensive national strength to strengthen international cooperation with major oil production countries and exporting countries in fields of politics, economy and trade and diplomacy.[42] This is unsettling for the US because of the delicate nature of its relations with the Middle East and the potential of oil revenue funding terrorist campaigns. As China has nothing to lose from strengthening its Arab relations in the region. Moreover, Beijing has no problem investing in the most non-democratic (and often anti-American) regimes in exchange for its oil access.

This strengthening of China's relations with the Middle East came full swing in the 90s as China exponentially increased economical partnerships with those oil exporting states in the middle east. Figure 2 shows the yearly amount of imported oil to China from eleven countries in the Middle East. Figure 2 shows the percentage of China's oil imports from the Middle East increasing over a span of twelve years.

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[42] Liangxiang, Jin. "Energy First China and the Middle East." *Middle East Quarterly*, Volume 12, No. 2, Spring 2005, PP 3-10. Middle East Forum. Web. December 2010

Figure 2. The Volume of China's Oil Imports, 1990-2002 (millions of barrels)[43]

Supplier	**1990**	**1992**	**1994**	**1996**	**1998**	**2000**	**2002**
Oman	6.00	22.34	24.58	41.28	42.29	114.32	58.73
Yemen	-	3.20	9.18	27.49	29.55	26.37	23.81
Iran	2.20	0.84	0.50	16.87	26.43	51.10	77.60
Saudi Arabia	-	1.37	1.07	1.68	13.19	41.83	83.15
Iraq	-	-	-	-	4.43	23.24	3.92
UAE	-	1.71	0.48	-	3.76	3.14	-
Kuwait	--	-	-	-	2.06	3.16	7.81
Qatar	-	-	-	-	-	11.67	3.34
Egypt	-	-	-	-	-	0.88	-
Libya	-	2.15	-	1.01	-	0.95	-
Algeria	-	-	0.05	-	-	-	-
Total from Middle East	**8.42**	**31.60**	**35.87**	**88.34**	**121.68**	**276.67**	**258.36**
Total Import	**21.33**	**82.91**	**90.13**	**165.10**	**199.45**	**512.94**	**506.67**
Percent of Middle East	**39.47**	**38.12**	**39.79**	**53.50**	**61.00**	**53.93**	**50.99**

[43] Liangxiang, Jin. "Energy First China and the Middle East." *Middle East Quarterly*, Volume 12, No. 2, Spring 2005, PP 3-10. Middle East Forum. Web. December 2010

While it clear China has put itself in the position of being heavily dependent on the Middle East for oil, its energy security strategies do not end in this region. The economic giant is also aware of the necessity to diversify foreign oil sources as a means of increasing its energy security. The various emerging oil industries around the world are very attractive to China, and many of them are still in its infancy. Therefore these industries welcome foreign investments. China is diversifying its foreign oil supplies by investing in large scale projects such as with the Canadian oil sand and Brazilian offshore oil industry. So as the US remains uneasy about China's growing presence in the Arab world, it feels even more threatened as the Asian giant increases its

presence in the Western World. It seems as if the US can no longer walk outside its front door without encountering China doing business with its neighbors.

There has been recent media focus on how the oil sands of Canada will change the global oil market sometime in the future once production can be made efficient. The US has been Canada's best customer for oil. But when it comes to the Canadian tar sands, environmental issues must be faced. A main one is that the tar sands industry increases CO2 emissions.

Another issue is the need to transport the proposed large amounts of oil that can be recovered from Canadian tar sands. The ongoing debate between the State Department and the Canadian oil officials center on the high environmental costs to the US that will accompany the proposed Canadian pipeline needed to transport Canadian oil to America. The production being in nearby Canada is irrelevant. Investing in the industry ties the US to its environmental consequences and means going against US laws aimed at lowering its CO^2 emissions. Canada requires billions of dollars in investments to produce oil from tar sands, and is now accepting funds from China, which has become its leading investor.

China's interests in Canadian oil shows how China's energy investments reach into America's very back yard. A recent article in the *Guardian*, discussed the most significant deal to date between the Chinese and Canadian government: a $1.9 billion agreement giving the Chinese oil company PetroChina a majority share in two major tar sands projects.[44] As China seeks to secure long term access of oil supplies outside of the Middle East (a US priority as well) unconventional oil sources that increase CO2 emission will damage its environmental reputation.

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[44] Goldenberg Suzanne. "Canada Looks to China to Exploit Oil Sands Rejected by US." *guardian.co.uk.* Guardian News and Media. 14 Feb. 2010. Web. 25 Mar. 2011. <http://www.guardian.co.uk/business/2010/feb/14/canada-china-investment-oil-sands>

To conclude this chapter on oil we have observed the beginning of the United States industry and the challenges associated with extracting, storing and transporting oil, the same as those challenges with alternative energy sources today. While oil has provided the world with a versatile and highly efficient energy source, it is a finite resource nonetheless and its production and use is the leading contributor to climate change.

Peak oil predictions have been proven accurate in the past and are shedding light on the world's future oil supplies. Even if unconventional methods of oil production can be made more efficient, these will also peak and decline. Decades later, the oil industry is still complicated as the very nature of an oil reservoir is still being researched. This foreshadows the complications the industry will face with the less experienced production of oil sands and oil shale. Offshore oil industries also face environmental scrutiny and production challenges.

Oil politics have shaped the foreign policy of nations that are incapable of producing oil domestically, thus being completely reliant on its access to oil-rich regions. The US spends a large amount of its budget on securing its oil access in the Middle East and as China does the same it threatens the (little) value of American presence in the region. The competition between China and the US has grown as the Asian giant gains political presence in oil rich nations. The indirect consequences of China's growing popularity in oil rich regions leaves the US feeling insecure in its ability to maintain its political influence in these critical energy-supply based regions.

Chapter 3. Alternative Energy

I. Alternative Energy Incentives.

There are various debates, increasingly discussed and made controversial by media, on the pros and cons of world's alternative and clean energy sources. While there are many options with alternative energy sources, their ability to replace fossil fuels efficiently have not yet been determined. Society needs an affordable and efficient energy source that can compete with the favorable prices and versatility of oil. What alternatives do offer are sources that are less environmentally damaging on a day to day basis. Leading industrial nations are faced with the dilemma of allowing an adequate budget for R&D with alternative energy production while still producing enough oil to fuel the nation.

It is important to note that energy use incorporates both a nation's electric power and fuel for transportation. The first is the more immediate and essential form. A power grid provides the necessary energy to make everyday necessities possible. The other need for energy is to fuel transportation mechanisms. Both industrial and residential life depend on the availability of transportation. We cannot have integrated world markets without means of getting both objects and people from one place to another, Whether by land, sea, or air. Alternative energy comes in various forms, and mainly contribute to the powering of a nation.

Before we can begin to discuss these nonconventional forms of energy production there are terminology distinctions that need clearing up between alternative, renewable, and clean energy types. The first two terminologies, alternative and renewable, are interchangeable. "Alternative energy" is commonly used as an umbrella term. Energy technologies not listed under

"alternative" possess undesirable consequences, and it is these consequences that the alternative options address. For this reason the alternative energy category and its components changes over time. An example can be seen with nuclear energy being removed from the group. Once the potential of a radioactive meltdown became a reality during the multiple accidents throughout nuclear power history, society has since preferred the alternatives to nuclear power. The widespread use of nuclear power also removes it as an alternative energy source since its production is now common. The "renewable" energy term is based on sources of infinite availability, and is a desirable trait within the alternative selections.

The last concept is that of "clean energy," which has increased in popularity due to the extensive research linking human activity to global warming. Clean energy sources overlap with those under renewable energy sources and include: geothermal, solar, wind, tidal, biomass, and hydroelectric energy. In a broader sense, clean energy can be seen as the most ideal form of alternative energy being both nonfinite and possessing little to no undesirable consequences.

Alternative energy investments in the past have fluctuated with the price of oil. When oil prices sky rocket, like they did during the 1970s oil embargo, the need for alternative energy becomes paramount in nations reliant on cheap oil imports. Once the oil embargo was lifted and prices stabilized, the alternative energy momentum unfortunately ended. This conditional interest in alternative energy has delayed its overall advancement and market potential. As long as there were no immediate needs to invest in alternative energy the industry lacked the necessary financial support for sufficient growth.

The only issue that has been capable of increasing world investments in alternative energy is that of climate change. In 2007 the Intergovernmental Panel on Climate Change (IPCC) for the

first time used stronger language in assessing the link between human activity and climate change. [45] The human activity that was given most of the blame was the burning of fossil fuels ,which release more CO2 (a greenhouse gas) into the atmosphere. The harmful onsequences of increased CO2 emissions causing climate change have been recorded all over the world. The increase in both the frequency and intensity of natural disasters is one critical effect. Now that there is are more pressing reasons to move away from fossil fuel dependency the alternative energy momentum has made a more permanent return. The difference is that climate change, unlike high oil prices, will not diminish requiring society to give greater attention to the problem and its solutions.

Climate change is a global concern and can only be mitigated by collective efforts. For industrial nations a main driver for alternative investments is energy security and following through with CO2 emissions reduction goals. In developing countries the prospects for energy access and economic development are the prime market movers, but despite their advancements the key markets for renewable energy today are in the industrialized countries (with limited exception of emerging economies such as China and India).[46] This however, does not compromise climate change mitigation efforts. Larger economies that burn the most fuel contributing significantly greater amounts of CO2 emissions and therefore are obligated to take the lead finding and implementing cleaner alternatives.

The challenges that the alternative energy industry face have been largely misunderstood. The media often exposes the pessimistic views of the industry, focusing on the technology being

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[45] Black, Richard. "Humans blamed for climate change." *BBC News - Home*. N.p., 2 Feb. 2007. Web. 16 Apr. 2011. <http://news.bbc.co.uk/2/hi/6321351.stm>

[46] United Nations Department of Economic and Social Affairs. *Increasing Global Renewable Market Share: Recent Trends and Perspectives*. Beijing International Renewable Energy Conference. 2005. Print. P7. Available at <http://www.un.org/esa/sustdev/sdissues/energy/op/beijing_re_egm/beijing_re_report.pdf>

too expensive for the every day consumer. The argument that clean energy is too costly at this state of its development is not a reasonable reason to abandon investments. As we have seen with the oil industry, a relatively new means of exploiting a resource efficiently takes time to fully understand and make affordable. Many of today's common technologies required years of expensive research, and overcame moments of failure. Perhaps the most common and taken for granted technology accessible to almost any individual's budget today is the internet.

The high speed internet has revolutionized the way people communicate with each other. What many do not know is that this technology took twenty years after its successful development, solely for military use, to enter the public market. This was possible in the US because of the intense computer technology research sparked by the space race with the USSR. When the USSR launched its Sputnik satellite the US needed to regain a technological lead. This motivated the government to spend significant amounts of the state budget on this very specific type of technology to achieve its goal of a competitive information-technology edge.

The challenges with alternative energy are mainly storage and transport based. The amount of energy from clean and renewable sources surpass that of fossil fuels. But it is very complicated to harvest and store that energy. This however shouldn't discourage investments since adequate research without large periods of commitment gaps will provide greater results. This type of determination was seen with yet another difficult technology that was developed in the US in record timing, the atomic bomb. Yet sheer government determination led to its success.

The short amount of time that was necessary for the US to master nuclear science is impressive. The nuclear bomb was created during a time with little to no knowledge of the necessary uranium and plutonium elements. It took a widespread campaign within various US universities and laboratories to create the first atomic bomb. In 1945 dollars, the atomic bomb

cost approximately 2 billion dollars to research and develop. During this research it took only 3 years for the first bomb to be developed, from the initial 1942 project approval to the 1945 testing and its successful deployment on Hiroshima Japan.

According to the US Inflation Calculator webpage, 2 billion in 1945 dollars is worth about $25 billion today.[47] Divided by three years this amounts to an annual budget of about $8 billion today. The 2012 US energy budget is only $5.4 billion for long term research and development, and $550 million for the Advanced Research Projects Agency.[48] While energy investments may not be as high as defense developments, recent trends in US government budget have shown an increase in investments for alternative energy. The argument has gone from alternatives being too costly, to how can we make this available technology more cost efficient.

When looking at the list of clean energy options one must ask which are most promising for every day use. Will just a few prevail over others or will a combination of sources be needed to fulfill our energy needs? How will this effect the global market and trade relations? I will discuss the difference between the various options as well as any challenges they face to further their efficiency and commercialization. These power sources include hydropower, geothermal heat, biomass, wind, and solar.

The first source I will discuss is hydropower. Hydropower or water power takes the energy from flowing water to create electrical power. Hydropower can be divided into two main groups; the more common group uses fresh water sources such as rivers to create energy; the other uses salt water or marine sources to create energy. While developments have been made with salt

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[47] US Inflation Calculator. *Inflation Calculator | Find US Dollar's Value from 1913-2011*. CoinNews Media Group LLC, n.d. Web. 17 Apr. 2011. <http://www.usinflationcalculator.com>

[48] The Budget For Fiscal Year 2012: Department Of Energy. *The White House: Office of Management and Budget.* 2011. Web. 17 Apr. 2011. <http://www.whitehouse.gov/sites/default/files/omb/budget/fy2012/assets/energy.pdf>

water sources converting tidal energy to make electricity, the technology has not advanced enough to be used efficiently. There are less than a dozen tidal turbine projects worldwide, and in the US alone it has arguably been taken seriously only in the last five years.[49]

When considering fresh water sources the most commonly used mechanism is that of a dam. Dams use the kinetic energy of flowing water to spin a turbine propeller, which is attached to a generator that produces electrical power. Dams are widely used for creating energy for the following reasons: they do not emit any pollutants thus contributing to government CO2 reduction goals; and their maintenance is cheaper than any other renewable resource due to its simple mechanical parts; and the amount of energy produced has a 90% efficiency rate and at half the costs of fossil fuel derived electricity.[50]

The benefits of dams have made hydroelectricity the largest renewable electricity source in world making up to 16% or 3 million gigawatt hours of global electricity.[51] In the United States, hydropower provides 96% of renewable energy and a total of 10% of US total electrical generating capacity.[52] Recent setbacks for hydropower development in the US (and in many other countries) are mainly due to the increase in environmental protection legislation. Negative affects on local river ecosystems can delay dam development plans however, recent design adjustment at the Technical University of Munich have been made to address this issue and could

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[49] Dorminey, Bruce. "Testing the Waters with Tidal Energy." *Scientific American.* Nature America Inc. 6 Dec. 2010. Web. 22 Apr. 2011. <http://www.scientificamerican.com/article.cfm?id=testing-the-waters-with-tidal-energy>

[50] United States. United States Army Corps of Engineers. *Hydropower Value to the Nation.* USACE, 2009. Print. 22 Apr. 2011. Available online at <http://www.corpsresults.us/docs/VTNHydropowerBro_loresprd.pdf>

[51] Australia. Clean Energy Council. *Clean Energy Council: Hydroelectricity.* CEC. 2011. Web. 22 Apr. 2011. <http://www.cleanenergycouncil.org.au/cec/technologies/hydro.html>

[52] United States. United States Department of the Interior. Bureau of Reclamation Power Resources Office. *Reclamation Managing: Water in the West: Hydroelectric Power.* USBR. July 2005. Print. 22 Apr. 2011. Available online at <http://www.usbr.gov/power/edu/pamphlet.pdf>

help this technology better comply with environmental legislation.[53] Once the new dam design is developed, Germany can use its patent to market the environmentally friendly design to countries eager to save their dams from environmental legislation. Foreign markets could include the US and China having outdated hydropower plants.

China's hydropower development peaked in the 1980s when development costs were compared to that of its cheap and abundant coal resources. More recent information however, suggests that the costs of hydropower facilities are low when calculated on a long-term basis, and normally costs only half that of a coal facility.[54] The "Three Gorges Dam" along the Yangtze River in central China is the largest in the world and is notorious for its extensive and devastating effects on both the local wildlife and human population.[55] Beijing, however, is reluctant to sacrifice economic gain for greater environmental protection and seeks to make hydropower alone over one-third of its total renewable energy production.[56]

Still, hydropower is overall an effective means towards lowering CO2 emissions and increasing renewable energy production. The technology and maintenance is relatively cheap and providing reliable electrical energy for long periods of time. While dam production can have harmful environmental effects, there are ways to reduce such effects by considering the unique needs of each site and by updating outdated projects.

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[53] Information on new hydropower design available at: <http://www.waterpowermagazine.com/story.asp?sectionCode=46&storyCode=2059406>

[54] "Hydropower: A Viable Solution for China's Energy Future? | Worldwatch Institute." *Worldwatch Institute.org*. N.p., 2011. Web. 23 Apr. 2011. <http://www.worldwatch.org/node/4908>

[55] Hvistendahl, Mara. "China's Three Gorges Dam: An Environmental Catastrophe?" *Scientific American*. Nature America, 25 Mar. 2008. Web. 23 Apr. 2011. <http://www.scientificamerican.com/article.cfm?id=chinas-three-gorges-dam-disaster>

[56] Ibid.

The next alternative source creates electricity from underground heat. This is known as geothermal energy. Geothermal heat is so powerful that it melts rocks within the earth's crust also known as magma. It is this intense heat that is used to turn water into steam which is then turned into electricity. While this method is not as discussed in the media compared to solar or wind technology the geothermal industry is rapidly growing. It provides electricity to over 52 million people worldwide and there has been a 52% increase in the number of countries actively pursuing geothermal projects.[57] These numbers are expected to increase as non-conventional geothermal production methods are now available.

Production is abundant where geothermal activity is at its highest near major tectonic plate boundaries. These areas are also known as "The Ring of Fire" traveling along the Pacific continental coasts. Along the Ring of Fire geothermal production is easiest since magma flows closer to the surface making high temperatures more accessible to be turned into electricity. Advancements with geothermal power production now extends beyond traditional hydrothermal reserves along the Ring of Fire. The successful development of innovative low-temperature geothermal technologies has allowed the market to expand, and now encompasses most of the world's nations.[58]

Geothermal power investments are expected to grow worldwide including in both China and the US. The US continues to take the lead in world geothermal electricity production.[59] As mentioned earlier new, low-temperature, pioneering geothermal technology has allowed the industry to spread in areas originally too difficult to harness underground heat. This has not only

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[57] Sustainable Business. "Geothermal Energy Powering 52M Worldwide." *Sustainablebusiness.com: News. N.p., 24 May. 2010. Web. 22 Apr. 2011. <http://www.sustainablebusiness.com/index.cfm/go/news.display/id/20367>*

[58] Ibid.

[59] Ibid.

expanded the industry globally, but also domestically across nations. In the US, geothermal energy production is now spreading from its early concentration in the west to states as far east as Louisiana.[60]

In China, geothermal energy is also becoming a promising means to increase domestic clean energy projects. Chinese officials now aim to have 15% of its alternative energy to come from geothermal sources by the year 2020.[61] Beijing's growing interest in geothermal energy is influenced by one of the industry's leading world producers, Iceland. President of Iceland Olafur Grimsson stated, "Both Premier Wen Jiaboa and Vice President Xi, who will be the next President of China, declared that on the basis of what China has done with Iceland in the field of geothermal, China now looks at Iceland as its primary partner in the geothermal transformation of China."[62] President Grimsson has also visited Los Angeles to formally open the headquarters of an Icelandic-American geothermal energy company, bringing its expertise to the US as well.[63]

Biofuels have gained international recognition as the world's most viable alternative fuel solution. Biomass is a general term including several methods of using plant matter and algae to create energy. Biofuels are the most popular products of the biomass industry since replacing fossil fuels are a top priority in countries trying to cut back on CO2 emissions and fuel imports. Ethanol fuel made from plant alcohol is the most common source of biofuel used today.

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[60] Geothermal Energy Association. "Geothermal Energy Association Yearly Update: Industry Poised for Ascendant Growth, Continuing Regional Expansion." *Geothermal Energy Association.* GEA. 30 Mar. 2011. Web. 22 Apr. 2011. <http://geo-energy.org/pressReleases/2011IndustryUpdate.aspx>

[61] Baker, Nathanael. "Iceland and China Establish Strategic Geothermal Partnership." *The Energy Collective.* Social Media Today LLC. 23 Dec. 2010. Web. 23 Apr. 2011. <http://theenergycollective.com/nathanaelbaker/48959/iceland-and-china-establish-strategic-geothermal-partnership>

[62] Ibid.

[63] Ricci James. "Local Icelanders' pride ignited: A visit to L.A. from their homeland's president for the opening of an energy headquarters sparks reminiscing." *Los Angeles Times.* Los Angeles Times. 12 Oct. 2007. Web. 23 Apr. 2011. <http://articles.latimes.com/2007/oct/12/local/me-iceland12>

The US has looked to Brazil as a model for increasing biofuel energy is achievable in every day life. The use of sugar cane based ethanol fuel is so successful in Brazil that it provides half of its transportation needs, pushing plans to double its ethanol production by 2019.[64] While the US is also a world leader in ethanol production its main feedstock is corn, not sugar cane. The difference is that sugar cane is far easier and economical to produce, without the expense of a high valued food crop like corn. Biofuel is the only alternative energy source in the world that has been successfully integrated into every day automobile fuel usage.

Biofuels have also caught the attention of China as its automobile industry continues to expand. Energy crops are now at the center of a broad debate in China and like the US, conflicts between using a nation's limited food resources (causing its price to increase) for energy has been difficult to overcome.[65] Unlike Brazil, China must feed its large population with limited arable land and had to stop using its wheat and corn crops for its ethanol industry.[66] However, like Brazil it has turned its attention to a non-food crop that is capable of successfully started up its ethanol industry again.

This miracle plant is a weed called Jatropha, which has several advantages over other oil-bearing crops. Jatropha is currently in the spotlight for many reasons: it does compete wit food crops since it can grow in a variety of landscapes; it requires less maintenance having a higher energy return on investment; it has a lower CO2 footprint than other oil-bearing crops; and from

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[64] Lavelle Mariann, Okray J. "Brazil Ethanol Looks to Sweeten More Gas Tanks." *National Geographic News.* National Geographic Society. 18 Nov. 2010 Web. 24 Apr. 2011. <http://news.nationalgeographic.com/news/energy/2010/11/101118/brazil-ethanol-gas-exports/>

[65] Fredrich Kahrl, Horst Weyerhaeuser, Su Yufang, Timm Tennigkeit. "Biofuels in China: An Analysis of the Opportunities and Challenges of Jatropha Curcas in Southwest China." *World Agroforestry Center.* ICRAF. (2007): 3 Print. 24 Apr. 2011. Available online at <https://jatropha.uni-hohenheim.de/fileadmin/einrichtungen/jatropha/Biofuels_in_China-An_Analysis_of_the_Opportunities_and_Challenges_of_Jatropha_Curcas_in_Southwest.pdf>

[66] Ibid.

a business perspective its major advantage is that it is not directly linked to international food prices.[67] Although this plant has not been cultivated to commercial quantities just yet, recent experimentations are being conducted to test if it can be used as an alternative aviation fuel.[68] If proven successful this could create a large market for Jatropha and the biofuel industry.

The next clean energy option, wind, is becoming more popular at a global scale. Wind energy uses the force of wind to spin a large turbine and create electricity. This form of energy requires massive structures scattered across open land and these require energy to make, maintain, repair, and transport. Despite these challenges wind energy has grown substantially in the past few years. In the US, the nation's fleet of wind plants grew 39% in 2009 alone avoiding an estimated 62 million tons of greenhouse gases annually.[69] Wind power investments have made this energy industry increasingly common across the US and abroad. While Germany and Spain remain major players in the wind energy industry, China has taken the lead from the EU and in 2010 just barely took the lead from the US.[70]

Since wind is not as limited to geography as fossil fuels are, its energy can be harnessed almost anywhere and the wind turbine technology is a relatively simple technology to make. What this means is that the industry supports energy independence, as it is very capable of being entirely manufactured and operated domestically. One aspect of wind energy that is unique to

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[67] Ibid. 4

[68] Spielberg, Greg. "Alternative Jet Fuel: The Jatropha Plant?" *Bloomberg Businessweek.* Bloomberg L.P, 7 Feb. 2009. Web. 24 Apr. 2011. <http://www.businessweek.com/bwdaily/dnflash/content/feb2009/db2009026_918710.htm>

[69] Zichal, Heather. "The Winds of Recovery are Blowing Across the Nation." *The White House.* The White House. 26 Jan. 2010. Web. 24 Apr. 2011. <http://www.whitehouse.gov/blog/2010/01/26/winds-recovery-are-blowing-across-nation>

[70] The Economist Online. "Alternative Energy | Wind From the East." *The Economist.* The Economist Newspaper. 3 Feb. 2011. Web. 24 Apr. 2011. <http://www.economist.com/blogs/dailychart/2011/02/daily_chart_alternative_energy>

some nations is their interests in unconventional offshore wind production. This is mostly being tested and developed in the European Union but could potentially work anywhere finances are available.

Either on land or at sea, wind is a promising clean energy source that can lead a nation to energy independence while simultaneously lowering its CO2 emissions. China is aware of this growing popularity with wind power aims to become a leader in wind technology exports in the global market. To achieve this ambitious goal, China's wind turbine suppliers have to pursue global business strategies not only for product sales but also for funding, supply chain, technology and operational expertise.[71] What this means is that China's must overcome the challenges of making the exporting process of these large turbine structures economically viable.

Some of the most advanced turbine technology companies are found in Europe, and is one resource of wind technology expertise that China simply cannot resist. In 2008, the Chinese company Goldwind acquired Vensys (a German wind turbine design company) and jointly developed and patented new wind turbine technology that it aims to sell to worldwide markets.[72] Wind developments demonstrate how countries can turn a domestic trade into a successful export commodity, by merging with foreign companies. While large scale shipping costs hinder China's booming export dreams, those smaller economies lacking domestic industry potential may be willing to pay high shipping costs to acquire the long term benefits of wind power.

The last clean energy resource I will discuss is solar power, one of the most popular in the group. Solar or photovoltaic panels seem to be society's best bet for implementing clean and

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[71] Gerson Lehrman Group. "Chinese Wind Turbine Manufacturers Global Expansion: The Dream and The Reality." *CWEI.org.cn.* CWEI. 9 May 2010. Web. 24 Apr. 2011. <http://www.cwei.org.cn/windpowerfor/News_Content.aspx?ID=3244&Type=2>

[72] Ibid.

renewable technology into any electrical grid system. This is because unlike other power sources solar panels can be used in close proximity to its power consumer. This benefit alone makes the energy intensive production, installation, and transport process of solar panels worth it. Solar panels can be placed on top of already existing buildings, private homes and even backyards. Solar energy has also proven to be capable of supplying large scale electrical power when open land is available for ample panel placement. This is usually seen in dry desert regions where both sunlight and open lands space are abundant being ideal for solar power .

Solar power has gained its present day status as a leading clean energy source because of its increasing ability to be used almost anywhere, and not just in desert terrain. In the US, solar energy projects did begin in the western states, which had the ideal conditions for their large scale use. However, US solar power use did not stop at its deserts. Currently, 25 American cities are taking steps that will make them solar energy market models contributing to the overall goal of making photovoltaic (PV) power cost-competitive with coal-based electricity by 2015.[73]

The global leader in solar panel use is a relatively cloudy country Germany. The partially cloudy skies of Germany have not discouraged its government from subsidizing its solar industry. It has achieved this not by technological breakthrough but by a law requiring the country's large old-line utility companies to subsidize the solar upstarts by buying their electricity at marked-up rates, making it easy for the solar industry to enter the utility grid and sell its energy to consumers.[74]

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[73] Solar Panels-Green Power. *Best Solar Areas: Solar America Cities. Solarpanelspower.net.* n.p, 2 May 2011. Web. 24 Apr. 2011. <http://solarpanelspower.net/solar-power/best-solar-areas-solar-america-cities>

[74] Whitlock, Craig. "Cloudy Germany a Powerhouse in Solar Energy." *The Washington Post* 5 May 2007. Web. 1 May 2011. <http://www.washingtonpost.com/wp-dyn/content/article/2007/05/04/AR2007050402466.html>

Ironically, Germany's enthusiasm for solar energy could potentially create a surplus and overload with its aging electricity grid.[75] The German Solar Industry Federation rejects the nation's energy agency concerns and proposes that the problem be resolved by simply updating the current outdated rural grid, and perhaps one day using the surplus to charge electric vehicles.[76]

China's solar panel businesses industry is both mature and competitive enough to succeed on a international level. China's solar industry is the biggest in the world capturing 40% of the global market.[77] Its solar success is similar to that of its wind power industry. China's overwhelming domestic energy demands provides emerging energy industries a lucrative market right at home. This combined with both government financial support and a large low cost labor force resulted in numerous solar manufacturers arising in China.

We have seen through this brief description of the major alternative energy industries how far they have matured. Clearly, their potential to become competitive in the global market is growing as investments pour in. The potential of these energy sources to provide solution to correct any environmental setbacks they may pose is increasing with further research. The majority of successful commercialization with upcoming clean energy industries demonstrates the necessity of global cooperation. While nations are eager to achieve energy independence, they must realize that the industries themselves benefit from transnational corporate merges. The sharing of information between nations and their clean energy industries will benefit the overall

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[75] NewScientist. *Solar Power Could Crash Germany's Grid.* 2784. Reed Business 27 Oct. 2010 Web. 24 Apr. 2011 <http://www.newscientist.com/article/mg20827842.800-solar-power-could-crash-germanys-grid.html>

[76] Ibid.

[77] Richardson, Michael. "China's Green Ambition, US Sees Red." *Yale Global Online.* Yale Center for the Study of Globalization. 5 Jan. 2011. Web. 26 Apr. 2011. http://yaleglobal.yale.edu/content/chinas-green-ambition-us-sees-red

progression of these emerging business. The technology is slowly becoming affordable as the adjustments towards making it an efficient energy to produce, store, and transport is improving with worldwide efforts to tackle these challenges simultaneously.

Each nation has its own budget, legislation, and unique experiences with the various clean energy industries. It is obvious that while nations want energy independence, they cannot help but seek each other out to fill in the technological blanks necessary to achieve their domestic industry potential. This creates new opportunities for international cooperation and we will see this potential and its political challenges in the next chapter.

II. *US-China Politics of Clean Energy.*

The world's desire for clean energy has grown substantially over the years going from a utopian-like fantasy, to a real business option for firms all over the world. In a world where change doesn't happen often (and when it does it moves at snail's pace), something incredible is happening with energy. The world is determined in its goal of integrating clean energy domestically by increasing investments. Both China and the US have also realized the benefits of thinking in long term goals with the progression of clean and renewable sources of energy.

A nation's energy security is critical for its survival, and clean energy has opened all new doors to achieving this. While oil is still a big part of that security, society is finally beginning to give attention to its replacements. China and the US, in their own ways and at their own speeds, are joining the worldwide race to developing a clean energy market. While clean energy

industries in the past experienced transient interests, the current concerns with today's energy and environmental issues aim to keep clean energy a long term government priority.

Clean energy development has become a real priority of the Obama administration with the long term goal of limiting US reliance on Middle Eastern oil ultimately gaining energy independence. The only way to achieve such long term goals is through greater clean energy legislative action, such as the American Recovery and Reinvestment Act, and through stronger efficiency standards for both appliances and automobiles.

While the US is making progress with recent initiatives and detailed planning, it has been criticized for not taking a greater lead with advancing and marketing these technologies. The world instead is looking towards Beijing for competitive prices. As we have already seen with wind turbines and solar panels, China is a major exporter when it comes to the most up to date clean energy technologies. The slowly emerging clean energy market has the potential to shift geopolitical power from oil rich countries to those with the most advanced solar and wind technology ready for export.

While many US industries continue to benefit from the cheap labor in China, the clean energy industry of the US is not one of them. Even with increases in minimum wage in China, relatively cheap labor is still a main reason for its ability to rapidly build an industry from scratch. The US has also long criticized China for artificially keeping its currency at low value, thus allowing it to dominate world markets. Clean energy technology is becoming one more market under Beijing belt.

The clean energy targets taking place in China are in line with those being taken by leading clean energy countries like the UK and Germany, according to Changhua Wu, the China Director

of the Climate Group organization.[78] China's combination of cost advantages, a clear policy framework, a dynamic and entrepreneurial business environment and abundant abatement opportunities, is proving that developing nations have as much, if not more, to gain from investment in low carbon solutions creating green-collar jobs, social benefits and economic growth.[79] US government however, is notorious for being incapable of consensus with energy.

The US has periodically claimed to be pro-alternative and taking every measure possible to push for clean, renewable energy development. While the world begs to differ, there have been some real targets made in its energy sector. These include making the wind and solar power use a reality across the American west, as well as introducing hybrid and electric cars into the automobile market. The difference is that China has taken things a step further and has gone from R&D to commercialization. Long before the US 2012 energy budget focusing on renewable technology, China initiated both stable and long-term government policies to push its domestic clean energy production.

China has reached a point of competitiveness when it comes to exporting its renewable products and the US can't help but struggle to catch up. As figure 2 demonstrates, the solar stocks over the past year (2010) has decreased for American companies (below the zero line) and increased for those stocks from China. This shows that government investments in the clean energy industry are far from resulting in diminishing returns, as was speculated in the past about the clean energy industry.

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[78] The Climate Group. "China Unleashes Clean Revolution." *The Climate Group* Official Site: News: July 31 2008. Web. September 2010. http://www.theclimategroup.org/our-news/news/2008/7/31/china-unleashes-clean-revolution/

[79] Ibid.

Figure 2. American and Chinese Solar Stocks 2010

Source. Hodge, Nick. "China's Clean Energy Future." *Energy & Capital's Weekend Edition*, 25 Sept. 2010, Energy & Capital Official Site. Web. December 2010. <http://www.energyandcapital.com/articles/chinas-clean-energy-future/1279>

While such investments and energy markets are booming in China, this is no small or easy task to accomplish. The recent economic recession in the US has certainly prevented it from taking the drastic measures that China's economy is willing to assume. China's commitment to renewable energy is expensive, although costs are falling steeply through mass production, wind energy is still 20 to 40 percent more expensive than coal-fired power and solar power is still at least twice as expensive as coal.[80] The Chinese government charges a renewable energy fee

[80] Ibid. P2.

increasing residential electricity bills by 0.25 percent to 0.4 percent, and for industrial users of electricity, the fee doubled in November to roughly 0.8 percent of the electricity bill.[81]

The Obama administration vowed in 2011 to transform the landscape of the US energy economy and eventually ease the nation's heavy reliance on foreign oil, but the follow up has been less than impressive. The problem arises when it comes to passing legislation to facilitate a more successful clean energy future. The ongoing trends (pursuit with nonconventional oil) in the US points to its inability to complete an all around comprehensive national energy reform. Luckily, the US clean energy campaign is successfully being kept alive by private investors and individual state proactivity.

China, by contrast has taken dynamic steps to reform its power sector over its two decades of economic growth. In many aspects, it has gone further than any other energy reforming country. Despite such admirable change, this does not Beijing an environmental hero. Its success in the clean energy industry spurs from its energy security needs as a developing nation with a large impoverished population.

China's quest for clean energy faces many challenges. Many of its citizens in rural areas live without electricity. It is important that a reliable power sector be established to support its growing population. China cannot achieve its ambitious development goals without upgrading its power supply capacity. This combined with its growing emissions problem and addiction to coal, makes the alternative energy industry the best solution for overcoming its energy challenges while reducing its overall CO2 emissions.

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[81] Ibid.

Chinese officials have taken the necessary steps to develop the nation's clean energy industries. China's Five Year Plan objectives are based on principles that by creating competition within its energy market and build competitive industries from within, helping it gain greater energy independence in the long run. This will boost its overall economy by the opening up of new businesses and jobs that will enhance its industry specialization.

While China is moving towards its domestic industry development, it can't help but consider the benefits of letting in foreign investors attracted to its many established energy industries and abundance of laborers. It has certainly learned to take into consideration more liberal economic practices, such as allowing an increase in private firms. If China wants more investments from abroad, it will need to demonstrate that it is capable of allowing private foreign firms to operate with minimal to no restrictions imposed by government. This will ease foreign investor's worries.

Greater transparency is another important factor within a liberal economy. Here, China has been very slow to adopt open or transparent communication with its state run industries. Lack of transparency is too risky from the point of view of foreign investors. Transparency is critical especially with technology based investors often worrying about losing their intellectual properties or patents that allow for their competitive market edge. China will need to assure investors that information related to their businesses will be made available to them. For example, creating a database in languages other than Chinese is essential to give foreign investors access to all business related documents and statistical records. The notorious secretive nature of China's state-run industries will have to overcome this image of corporate secrecy to create a more inviting environment for investors abroad.

When looking at corporate governance, the US has all the experience it needs to turn innovation into a profitable business. It has recently taken its own unique steps to bring to life its green society and clean energy goals. As previously mentioned these efforts by the Obama administration are satisfying in theory, but lack results in its real world practice. Despite its shortcomings, America's new energy securing strategy is worth mentioning. There are five main initiatives to its new comprehensive energy securing strategy.

The first is the American Recovery and Reinvestment Act. This effort to jumpstart the American economy was signed by President Obama in February of 2009 and is intended to save and create millions of American jobs.[82] Its goals include the following: setting the groundwork for the new clean energy economy, revitalizing infrastructure and transportation, updating health information technology, advancing vehicle and fuel efficiency, and finally building a better, smarter, electric grid.[83] This requires substantial financial backing for large scale projects and sufficient R&D, and is highly unlikely to be completed any time soon under current US economic conditions.

The remaining initiatives focus on specific legislative action and have seen better results. The aim is clearly to guide the nation away from fossil fuel consumption and more towards energy efficiency. The remaining initiatives includes, appliance and automobile efficiency standards, reducing greenhouse gas emissions, and making private homes more energy efficient. Efficiency standards have already been put into effect for appliances and automobiles, and

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[82] The White House. *The Recovery Act: About the Recovery Act.* n.p, n.d.,Web. 24 Apr. 2011. <http://www.whitehouse.gov/recovery/about>

[83] Ibid.

decreasing US CO2 emissions is being done by utilizing clean energy technology where it can be afforded (mainly with businesses seeking a modern edge).

The US may have the political tools to set the stage for a more informed and energy conscious society, but it currently lacks ideal financial conditions to subsidize infant industries. Oil industries guarantee profits, while clean energy industries have to be incorporated into current outdated electrical systems which takes more time and money. As for transportation, this is an even more difficult task. For example, the highly anticipated electric vehicle is available at affordable commercial rates due to private industry initiative. What is needed are updates with infrastructural systems such as public charging stations (like gas stations) allowing for consumers to transition from gas to electric vehicles.

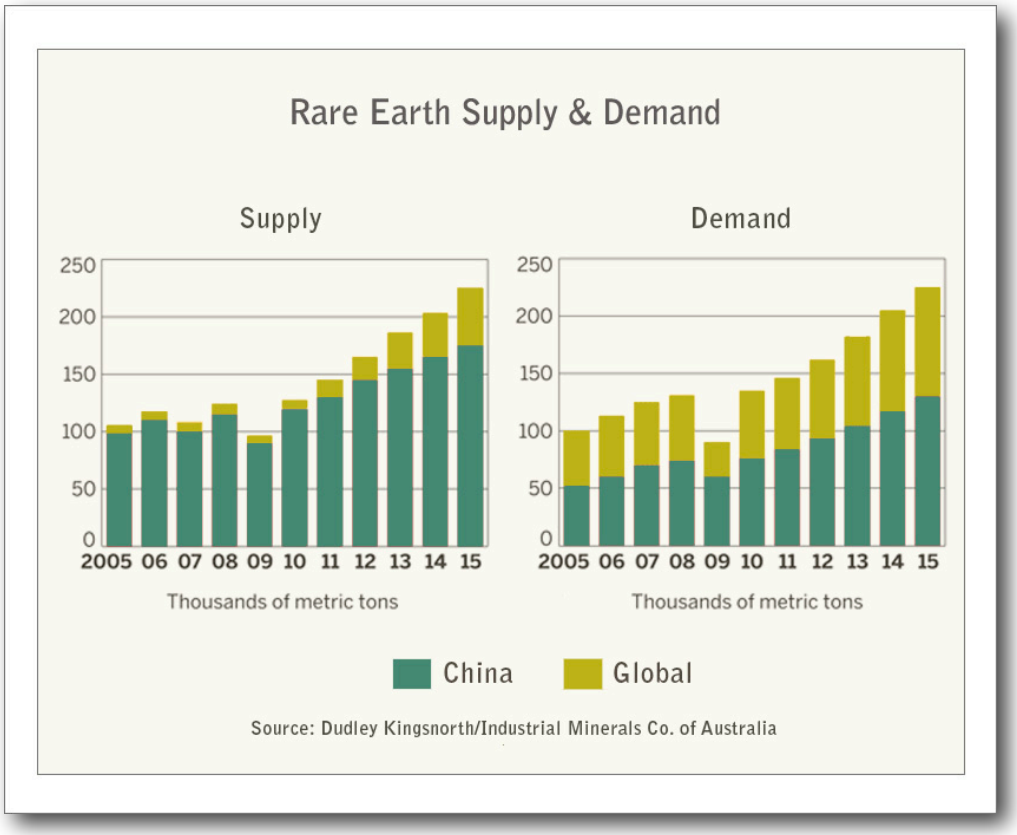
Clean energy facilities in America are some of the most sophisticated in the world, however they are too few and far apart. The technology is improving and demands are growing with recent polls showing public support for going green. What is lacking in the US are the large scale adjustments in infrastructure allowing clean energy technology (such as solar power and electric cars) to be incorporated in every day life, and support for those industries that are currently understaffed requiring a more specialized work force. No emerging industry will prosper without the necessary skills and knowledge to keep up innovation.

While China has the workforce for its clean energy development, there is yet another market advantage exclusive to China that can further US and other nations's reliance on it not just for its technology, but for its abundance in a critical resource. China has a key advantage in the alternative energy market as it possesses the world's biggest reserves of rare-earth minerals, essential to producing the world's newest technologies; military applications, electric motors and

batteries for hybrid cars, wind-power turbines and solar panels, energy-efficient light bulbs, fiber optics, glass additives, and so on.[84]

In a technology-intensive world, rare earth minerals have become some of the most sought-after resources in modern manufacturing even though they're used in relatively small amounts, its increasing market value could be to China what oil was to the Middle East.[85] Figure 3 shows China's supply-demand ratio is in its favor as oppose to the rest of the world.

Figure 3. Rare Earth Supply & Demand



Source. 84 Richardson, Michael. "China's chokehold on Rare-Earth Minerals Raises Concerns." Yale Global Online, October 8, 2010. Web. December 2010. <http://yaleglobal.yale.edu/content/chinas-rare-earth-minerals>

[84] R. Michael. "China's chokehold on Rare-Earth Minerals Raises Concerns." *Yale Global Online*, October 8, 2010. Web. December 2010. <http://yaleglobal.yale.edu/content/chinas-rare-earth-minerals>

[85] Ibid.

China is fully aware of its capabilities to monopolize the rare-earth minerals market. Due to its own high demands for the minerals and its increasing global value, China has begun to limit trade access to its mineral resources, raising concerns that China is taking advantage of its capabilities. This concern was heightened in 2010 when Japan, the world's biggest importer of rare earths, reported that China had temporarily blocked all shipments due to political tensions.[86]

Some experts contend that China's dominance in the control of market output of rare-earth mineral supplies not only threatens US energy security but also its military capabilities. These minerals are critical for the manufacturing of US advanced military equipment as well. If China continues to use its mineral export blocks as a political tool it could one day restrict exports to the US, resulting in critical military production delays for the US during times of war. In short, this us just another challenge that the two nations have to overcome to better their trade relations. The US needs to use remind China how important fair trade policies are towards maintaining a good political standing with nations in the global market.

According to an article in the *New York Times*, China reduced its export quota for rare earths for the second half of this year by 72 percent, as exporters had only six weeks of quotas left when China imposed its unannounced embargo on shipments to Japan.[87] China, however, disputes these accusations that it is taking advantage of its mineral exporting position. China's Commerce Ministry claimed that prior reports by an anonymous official stating that China would cut its global mineral export by 30% in 2011 are false.[88]

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[86] Ibid.

[87] Bradsher, Keith. "China Said to Widen Its Embargo of Minerals." *The New York Time*s, October 19, 2010. P2. Web. December 2010. <http://www.nytimes.com/2010/10/20/business/global/20rare.html?pagewanted=1&_r=1>

[88] Jiang, Steven. "China Denies Reports on Halting Export of Rare Earth." *CNN World*, October 20, 2010. Web. December 2010. <http://www.cnn.com/2010/WORLD/asiapcf/10/20/china.rare.earth/index.html?section=money_topstories>

It is unlikely that China will cease to see the benefits compliance with the global market for Rare Earth Minerals. China's cap on rare earth mineral exports are also meant to attract foreign companies to join its local enterprises. Such business practices are a learning curve for China, as with clean energy technology such as solar panels are, have also been protected in this way and has not helped its corporate image. Because of increasing pressures from the WTO, however, China has changed its course. It will continue to supply rare earths to the international market and manage export quotas in accordance with WTO regulations, according to Commerce Ministry spokesman Yao Jian.[89]

The US and China face very different challenges when it comes to developing their clean energy sector. We have seen that the technology is improving and gaining much attention throughout various nations. Even oil rich economies are using their oil revenues to fund clean technology projects, now seen with Brazil and even Saudi Arabia. While the world has relied on the US for the answers to most pressing problems, the need for efficient clean energy technology is one goal that the world hegemony cannot achieve alone. These industries are growing domestically all over the world, including in the US, but need more than just home grown facilities to reach it full market potential.

The clean energy market needs more time to develop into an abundance of energy technology companies that are both mature and offer competitive rates. However, the scope at which these industries are located around the world allows for each to take on unique challenges of their home nation. For example, nations that are adamant on their environmental protection standards, will produce technologies that better cater to these rules.

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[89] Blanchard, Ben and Miles, Tom. "China 2010 rare earth exports slip, value rockets." *Reuters*.com, Thomson Reuters Corp. 19 Jan. 2011. Web. 26 Apr. 2011. <http://af.reuters.com/article/metalsNews/idAFTOE70I03O20110119>

When new developments do occur within the energy industry, they become very attractive to the rest of the world working on the exact same product and are eager to be up to current standards with these industries. If the US focuses on solar power it could potentially compete with the turbine export goals of China, meanwhile Germany's commitments to solar panel use could one day lead to a breakthrough in storing solar energy making it possible to use in more cloudy cities. Once a clean energy technology breaks barriers in one nation, others that desire the same advancements will create a new market for those patented technologies, as well as a new source of income and competitive edge for its host country.

II. Energy Policy Proposals.

When it comes to the US and China, trade is nothing new to their relationship. The worldwide campaign against climate change has sparked a race to finding the newest markable energy technology that can replace fossil fuels. In the front of this race is China with the US behind but trying to catch up. The US been keeping an eye on what China has been doing, and in moments of China's economic triumphs it creates motivation for US to push its own potential. As China's clean energy industries grow, the US should be looking towards how it can get a piece of the action and not bask in its many excuses for lack of industrial progress.

There seems to be a repetitive routine between the US and China resembling a love-hate relationship. While the US remains China's best customer, any time the balance tips in China's favor the US can't help but expose China's faults without looking at its own. For example, the US-China trade deficit has only increased over the years as the US continually imports more from China than it can export. From China's perspective it feel that it should not be blamed for

the apparent lack in competition from US domestic industries. This argument is true according to economists who cautioned against oversimplifying the solution to the imbalance, saying that there needed to be a change in consumer preferences in the United States along with any change in policy.[90]

China's undemocratic centralized political system, unlike that of the US, has allowed it to mobilize its resources to focus on energy goals deemed vital by those with power. The US is struggling to move forward with clean energy because of the restrictions on its government to demand stringer clean energy legislation at will. This has resulted in a lack of experience when compared to the clean energy history of those developing nations such as China, and even Brazil as we have seen with its ethanol fuel industry. The US can take advantage of China's mature clean energy industries by merging with its companies currently dominating the global market.

The US has too long focused on the consequences of an energy market future based in Asia, while simultaneously not being proactive enough within its own borders to promote domestic clean energy at home. This mentality will result in the US being out of the energy market loop and still left to worry about energy independence as others are actually achieving it.

The US needs to partner with other economies that are pushing forward with clean energy, these world leaders include China, Germany and Spain. China may not have the most liberal business practices, but it will certainly learn as its domestic market value increases so will global pressures for its clean energy technology and rare earth minerals. What the US should be doing is working with China to establish a more liberal energy market that will benefit all. The US is not the only nation that can do this as others seek a piece of China's clean energy empire,

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[90] Hauser, Christine. "U.S. Trade Deficit With China Widens." *nytimes.com* The New York Times. 14 Oct. 2010. Web. 26 Apr 2011. <http://www.nytimes.com/2010/10/15/business/economy/15econ.html>

they too will require China to make its industries safer for foreign investors to come in without feeling shut out by Chinese government officials.

As China is becoming an economic superpower it must learn to change its traditional corporate values for those of corporate governance. Corporate governance creates market confidence and competitiveness. Corporate governance principles portrays an overall sense of trust and fairness between business players, and can be achieved by such corporate behaviors that ensure transparency and disclosure of valuable information.

China is still learning the benefits of good corporate governance as it is a fairly new concept to its officials, who are used to complete control over their businesses. But as China grows and gains more attention abroad, it will need to adapt to the wants and desires of foreign investors and ensure that its businesses are welcoming and add up to foreign liberal expectation. China has the advantage of being a late developer and can learn from others mistakes. A main challenge for China is to create institutions that will open doors *to* its markets and promote private industry expansion.

The US and China are beginning to adapt new strategies for peaceful economic coexistence. According to an article in *China Daily*, "Washington has observed that the US should not go back to the old ways of the former administration, maintaining a tough relationship with Beijing."[91] When it comes to energy security, better Asian relations can help the US avoid another difficult scenario with tension between an energy providing region. There is no reason Beijing can't learn from the US, while the US partners with its energy industries.

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[91] Shuo, Huang. "US- China Ties: Trustworthy Friend is Final Goal." *ChinaDaily.* CDIC. 23 Oct. 2010. Web. 26 Apr 2011 <http://www.chinadaily.com.cn/opinion/2010-10/23/content_11449505.htm>

The clean energy industry provides a unique opportunity as a sphere of collaboration for the US and China since both nations face similar energy security challenges. While there are realist tendencies in every nation to ultimately do what is best for its own economy, when it comes to the clean energy market collaboration is better than competition. China and the US, although very different culturally, face the same problems with their fossil fuel addiction. In their attempts to greater their clean energy sector and lower CO2 emissions, they should build upon each others success and work together to create competitive energy industries and ease the world's addiction to fossil fuels, as well their own.

Chapter 4: Conclusion

When it comes to its energy needs, society is experiencing unprecedented challenges. The world's oil supplies are peaking or have already peaked, making what was once a secure resource one that is becoming less abundant and more expensive to produce resulting in increased price volatility. These insecurities with oil supplies are causing oil consuming nations to desperately seek other oil markets that may be emerging in unconventional forms, while those nations who have these rare sources of oil to invest heavily in them.

The problem of climate change, however, puts pressure on nations to almost go against its survival instincts and not invest heavily in fossil fuels despite their economic value. Climate change mitigation requires states to lower their overall CO2 emissions, which are primarily caused by the burning of fossil fuels. In short, oil is causing a lot of debate on whether it is best to leave this traditional energy source completely behind, or take advantage of its increasing rarity and the economic gains from domestic investments.

When we look at the unconventional oil industries, they only add to the problem of CO2 emissions and other environmental set backs. Many unconventional oil sources are not even considered "proven reserves" since they have yet to enter full production capacity, as seen with offshore oil exploration. Unconventional oil production may delay global oil peak to some degree if made efficient, but as they are very expensive to produce and cause more environmental damage than the traditional methods of oil production, these industries instead are facing their own developmental delays. While these oil resources may be abundant, increasing concerns with CO2 emissions and a growing clean energy market will eventually leave these potential oil industries facing diminishing returns as global demands decline.

The world has multiple options when it comes to alternative energy solution to oil. These options are not only clean but are completely self sustaining and will ultimately be a revolutionary move forward for society once they are developed efficiently. There is no doubt that clean energy will replace oil since its production cannot go on forever. The only question that remains is not so much when, but who will lead the world's victory away from fossil fuels.

Clean energy technology has seen vast improvements in just under a decade becoming a global trend for media all over the world to talk about. The discussion of clean energy technology has certainly seen a shift in the recent years. What was once considered too expensive and unlikely to be made commercially for every day use, is now being seen for its energy providing potential and job creating opportunity. The clean energy industry has certainly become an attractive business all over the world, and will change the way nations seek energy security.

When it comes to international relations, the clean energy revolution is one that can change the face of global trade relations and geo-political power. As oil becomes a thing of the past the Middle East will lose its energy reign losing its most prized buyers, the US and China. This of course is on the agenda for these leading economies because energy independence remains the ultimate goal. What needs to be realized is that these goals can be better achieved through cooperation, and not by market isolation and protectionist policies.

The clean energy industries around the world are growing and seeing real results in its commercial capabilities. From China to the US and in between both industrial and developing nations are starting to take clean energy seriously. From large solar and wind farms, to hydro and geothermal power, cars than run on ethanol and cars that are completely electric, there is an

abundance of options for a nation to tap into its clean energy resources and inch closer to energy independence.

We have observed with China's growing clean energy market that its one party system allowed the economic giant to mobilize its resources better than the US. However, as China aims to continue on its current track of economic growth while providing for its growing energy demands, it has realized the necessity of welcoming foreign investments to strengthen its position in the international market. This requires greater transparency and is a major challenge for its centralized system as traditional policies of business being controlled by elites has allowed it to prosper thus far.

On the contrary the US faces very different challenges. Its decentralized system means there are more to please, making government consensus difficult to reach. It has a current budget crisis to overcome making it difficult to mobilize its resources. The main advantage in the US is in its ability to create incentives for private industries to develop. The US can help its energy industries domestically with subsidies and tax credits, but it can also benefit from collaborating with those industries abroad. While energy has always been an arena for global competition the common interests with clean energy is an ideal place for collective action, and China has a mature clean energy market for this type of partnership.

The competitive nature of the US and China is no surprise when looked at from a neorealist perspective. In a world where globalization exists in anarchy, the survival instincts of states can lead to political tensions as pressures are exerted on them by international competition. This is clear when energy security revolves on geographically limited finite resources such as oil.

Waltz reinforces this survival instinct of states as they are more focused on relative gains to each other increasing their competitive nature and mistrust in one another.[92]

China can be described as following policies of neomercantalism; a derivative of neorealism that can be found in Gilpin's studies on Asian markets.[93] Neomercantalism encourages exports and government intervention along with protectionist policies to maximize a nation's market potential. This explains the behavior of China and why it will be difficult for its elites to stray from policies that are designed to develop a competitive lead in the global market.

The international energy market displays certain aspects of game theory such as lack of trust between nations also known as "prisoners dilemma."[94] When it comes to the global market nations are expected to follow certain rules set up by organization such as the WTO. But when a nation is suspected of "cheating" such rules a nation's behavior complies with that of the prisoners dilemma theory. This can be seen as ongoing between with the trade relations between the US and China within, and beyond, the energy market. Lack of trust makes cooperation difficult in international relations as states desire to maximize their relative gains to others.

There is reason to believe despite the apparent realist tendencies of states, that there are greater benefits with collaboration when it comes to clean energy. The "collective action problem" can be seen with the international energy market as countries will only benefit through collective efforts to develop clean energy technologies. This is because clean energy requires short term economic sacrifices (high investments costs in inexperienced industries) that states,

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[92] Waltz, Kenneth. *International Relations Theory.* New York: McGraw Hill, 1970. Print

[93] Gilpin, Robert, and Jean M. Gilpin. *Global political economy: understanding the international economic order*. Princeton, N.J.: Princeton University Press, 2001. Print.

[94] Axelrod, Robert M.. *The evolution of cooperation* . New York: Basic Books, 1984. Print.

most notably the US, refuse to take on alone. But if states continue to make sacrifices to develop a clean energy market, their collective efforts would yield faster results for the energy market and bring about energy independence. This can also be seen with the goals of lowering CO2 emissions, as nations realize that only united efforts can mitigate the negative effects of climate change.

The efficiency of private markets and pressures for greater transparency that face state run industries are all aspects of neoliberalism.[95] Neoliberalism also examines the conditions and strategies that maximize the chances of collective action and policy coordination in the wider interest. Neoliberalism also shows how focusing on absolute gains (not relative ones) is essential to managing the challenges with climate change. While the oil market has indeed created an insecure and highly competitive dynamic among state, we have also seen that clean energy opens up opportunities for cooperation among states in ways that will benefit all participants.

Clean energy technologies needs perfecting when it comes to both transportation and storage. These challenged require long-term R&D investments that put short term goals aside and make energy independence the real objective. Clean energy is still very expensive to develop and only the most developed and persistent nations will succeed in making it affordable to all. If nations carry this burden together the larger benefit to the global ecosystem will benefit everyone, rich and poor countries alike. It is ironic but true that with clean energy industries, international collective efforts increase the likelihood that nations will achieve their ultimate goal of energy independence.

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[95] Keohane, Robert O.. After hegemony: cooperation and discord in the world political economy. Princeton, N.J.: Princeton University Press, 1984. Print.

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