BIOFUELS: THE SECURITY THREATS OF A SECURITY SOLUTION

Emily Rose Wullenweber

A thesis submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Political Science, Concentration TransAtlantic Studies.

Chapel Hill
2008

Approved by:

John D. Stephens

Gary Marks

Liesbet Hooghe

ABSTRACT

EMILY WULLENWEBER: Biofuels: The Security Threats of a Security Solution
(Under the direction of John D. Stephens)

The production and consumption of biofuels throughout the industrialized nations of the globe has not been to create a response to growing environmental concerns but rather an effort to address the increasing threats posed by issues of energy security, as well as to create new economically advantageous markets outside of traditional fossil fuels, and while being initially hailed as an energy security solution the results have led to new multifaceted security threats to all nations, especially those in the developing world.

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I. Introduction

The growing pursuit and subsidization of biofuels throughout the United States and Europe has caused great concern throughout many political, environmental and scientific communities on a global scale due to increasing awareness of negative externalities associated with their production and consumption. Of specific interest and concern for many countries is the development of biomass energy from the inputs of ‘energy crops’. Produced from these energy crops, liquid biofuels such as ethanol and biodiesel are increasingly being used for transport. The prominence of these fuels has grown at astounding rates, with global fuel ethanol production more than doubling between 2001 and 2006 and biodiesel seeing a six fold increase in the same period. The rapid growth of these fuel alternatives is largely attributable to the adaptability of biofuels which are capable of operation in existing motors (WorldWatch, 2007, 1), as well as the promotion of such fuels as environmentally friendly, as will be demonstrated later, throughout the media to mainstream society. This article will argue that the primary motivation behind production and consumption of biofuels throughout the industrialized nations of the globe has not been to create a response to growing environmental concerns but rather an effort to address the increasing threats posed by issues of energy security, as well as to create new economically advantageous markets outside of traditional fossil fuels, the results of which have led to new multifaceted security threats to all nations, especially those in the developing world. “The widespread use of biofuels is likely to be an environmental and social disaster (AEF, 2007, 1).”

II. Proposed and Enacted Biofuel Policies

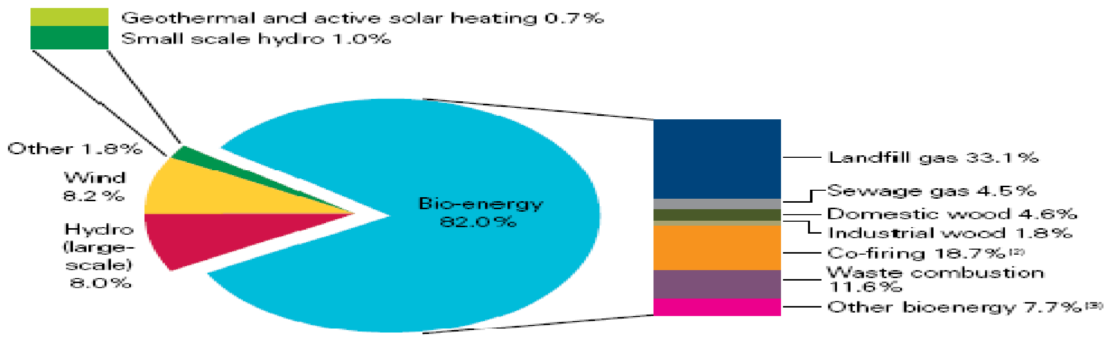
Government initiatives and legislation implemented throughout the US and Europe both promote and mandate the production and use of biofuels. Such policies include the Biofuels Directive in the EU, Renewables UK in the United Kingdom, and the Renewable Fuel Program outlined in the Energy Policy Act in the United States.

When examining the targets in the EU draft of the Biofuels Directive, there is a clear future for a substantial market for renewable transport biofuels (Shanahan, 2003, 77). The directive creates a mandatory share scheme with minimum blending shares of biofuels and traditional fossil fuels, demanding an overall 5.75 percent of fuel consumption dedicated to that of biofuels (Bozbas, 2008, 548). In article one, the directive reads, "This Directive aims at promoting the use of biofuels or other renewable fuels to replace diesel or petrol for transport purposes in each Member State, with a view to contributing to objectives such as meeting climate change commitments, environmentally friendly security of supply and promoting renewable energy sources (European Commission, 2003, 3)." The directive goes on to explain the need for member states to consider the overall climate and environmental balance of different types of biofuels and other renewable energies and to show priority for those which demonstrate "a good cost-effective environmental balance, while also taking into account competitiveness and security of supply (European Commission, 2003, 4)." It is important to note that the stated goals are largely pronounced with environmental concerns with an economic and energy security undertone, the successes of each which will be discussed later.

Additionally, on a national level throughout Europe, governments have created incentives by reducing the taxes on biodiesel in an effort to create a market for new farmers on ‘empty’ land, the results of which led to great increases in biodiesel production, most notably in Germany. Biodiesel represents 82 percent of the biofuel production in the EU, by far the preferred renewable biofuel in the Union (Bozbas, 2005, 546).

The UK demonstrates a specific example of an ambitious national policy within the European Union, which established its own program, Renewables UK. Launched in March 2002, the British initiative increased its support for biofuels and related technology (IMechE, 2003, 79). The policy suggested that, “for heat and electricity, it may be one of the most cost-effective ways to meet the EU 2020 renewable energy target, as well as delivering significant carbon savings.” The UK estimates an achievable 14% renewable heat and up to 37% renewable electricity would require 4.5% of the UK’s forecast energy consumption in 2020 to come from biofuel, or nearly one third of the proposed UK share of the EU target (BERR, 2007, 181). As the chart below demonstrates, since the implementation of Renewables UK in 2002, the UK has put a great deal of stock in biofuels, more so than any other sector, in regards to renewable energies (BERR, 2006, 183).

Figure 7.2: Bioenergy utilisation as a % of total renewable energy utilisation 2006[1]



Total renewables used = 4.43 million tonnes of oil equivalent

Source: BERR, 2007, *'Digest of UK Energy Statistics'*

(1) Excludes all passive use of solar energy and all non-biodegradable wastes. In this chart renewables are measured in primary input terms.

(2) Biomass co-fired with fossil fuels in power stations; imported 11.2% of total renewables, home produced 7.5%

(3) 'Other bioenergy' include farm waste, poultry litter, meat and bone, and short rotation coppice.

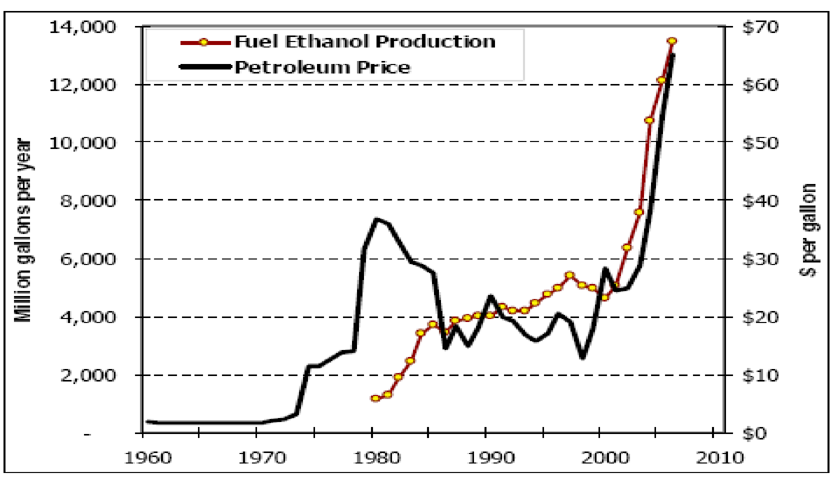
On the other side of the Atlantic, the large ethanol industries first developed in Brazil and the US throughout the 1980s have entered a new growth phase in the past few years, exporting policy ideas and technologies around the globe (WorldWatch, 2007, xvii-5). The Renewable Fuel Program outlined in the Energy Policy Act in the United States calls for the production of 7.5 billion gallons of ethanol biofuel by 2012 (Kammen, 2008, 63). More specifically the United States Environmental Protection Agency, which was given authority to revise and implement regulations on gas sold in the United States under the Energy Independence and Security Act of 2007, revised the Renewable Fuel Standard Program in 2008 to increase the blend of biofuel and gasoline to 9 billion gallons for 2008 to 36 billion gallons by 2022 (EPA, 2008, 1). These recent revisions which have been passed in the United States by its agency responsible to environmental protection largely increase the prominence of biofuels within the US transport sector despite scientific evidence, which will be discussed later, highlighting environmental concerns surrounding the use of such fuels.

Falling in line with Europe, the US and Brazil, other countries have begun to make major commitments to biofuels including China, Colombia, India, the Philippines and Thailand (WorldWatch, 2007, xviii). With the increasingly high number of nations creating energy policies focused on the use of biofuels, it is clear that the level of production will continue to dramatically rise, despite the great deal of uncertainty and controversy surrounding the environmental effects of these fuels, which will be discussed later. This widespread implementation of such biofuel policies brings to light the underlying economic motivations for the leaders of industrialized nations which create prosperous conditions in their countries.

III. Market Forces

A clear positive relationship between market forces and biofuel production can be seen when studying market conditions and the level of production of biofuels over a given period of time. In the 1940's, a plethora of cheap oil was available, virtually eliminating any existence of biofuels from the market which had a nominal presence at the time (WorldWatch, 2007, 5). When examining the chart below from *Energy*, beginning in the 1980's as the market price for petroleum began to rise, so did the demand for alternative methods of transport fuel. During this era of peak oil prices biofuels made a strong reappearance, confirming a positive relationship between the two.

Figure 1. **Worldwide fuel ethanol production and petroleum prices**



Source: Kammen, 2007, pg.45
Petroleum prices were based from www.bp.com; Ethanol Production is from the Renewable Fuels Association www.ethanolrfa.org

This symbiotic relationship further solidifies the claim that there is a strong motivation for the production of biofuels, not primarily for environmental protection and 'green energy', but due to the demands of a capital market. In a report published by the OECD, it is noted that environmental impacts of biofuels are often not measured, let alone use to guide government regulation (Kammen, 2008, 46). Lee Raymond, the chairman of ExxonMobil, noted "Energy is the biggest business in the world. There just isn't any other industry that begins to compare. Energy is the very fuel of society, and societies without access to competitive energy suffer." The World Energy Council estimates that $30 trillion of global investment will have gone towards energy between 1990 and 2020 (Vaitheeswaran, 2005, 46). In regards to biofuel, production and investment has primarily taken the form of ethanol for the purpose of ethanol and oil blend based petroleum, the negative environmental effects of which will be discussed later. Upon examining this positive relationship and the given power of the 'market', when it comes to the research and production of alternative energy, the environment cannot easily compete with the advantageous financial possibilities offered to policy makers via biofuels.

IV. Economic Incentives

In this section, the economic incentives which explain a driving force behind biofuel production, most notably in the areas of agriculture and overall employment, will be presented. From a government perspective, there is vast potential in countries with a large agricultural sector of the economy to invest in biofuels and thus decrease their reliance on traditionally imported fossil fuel based oil (IMechE, 2003, 90). An article published in *Energy* asserts that the original productions of biofuels were often motivated, as is now, by an attempt to provide agricultural support (Kammen, 2008, 68). Even as far back as the onset of the industrial revolution, Henry Ford and Rudolph Diesel advocated the use of liquid fuels as a way for expanding the market in regards to farm products (WorldWatch, 2007, 120). Much of the world's poor depends on the agricultural economy as a means of survival, so the argument can be made that the further development of biofuels could eliminate a level of poverty by providing financial incentives to those with available land to produce necessary feedstock used in production. Not only would this new sector of the agricultural economy benefit those who produced the feedstock, but theoretically if the process gained efficiency it would also benefit those who were buying the cheaper domestically produced fuels and the domestic economy overall. Europe accounted for 73 percent of the worldwide production of biodiesel in 2006 using primarily rapeseed and sunflower seeds. In 2005, 1.4 million hectacres of rapeseed were planted specifically for biodiesel throughout Europe, illustrating the growing market in biodiesel (Smith, 2007, 1). In other parts of the world countries rely on other plant oils, such as soybeans in the United States and palm oil in many of the more tropical regions of the globe. In the productions of ethanol based biofuels, a variety of sugar and starch crops are utilized, such as sugar cane, sugar beet tubers, corn, wheat and cassava, with the largest productions coming from Brazil in the form of sugar cane and the US from corn. The majority of costs associated with the production of biofuels come from these feedstocks themselves, thus creating the profitable market in agriculture. The significance of feedstock choices used for production also illuminates the motivations for creating a domestic market for fuel supply rather than ultimate efficiency, as the preferred feedstock is typically that which is most commonly grown in each producing country and not necessarily that which is proven to be most efficient and environmentally friendly, reinforcing the growing demand for energy independence due to historically unstable fuel markets. The creation of new agricultural markets has had an apparent advantage for economies as a whole, thus highlighting it as one of the major drives behind past and current biofuel production and implementation policies.

Financial gains for those already involved in the agricultural economy aside, in regards to employment it is a general rule that with the implementation of new technologies, new jobs will be needed to fill these new sectors and requirements of the market. If biofuels are to be a source of energy, individuals are needed to grow and harvest the necessary crops, to create the fuel from the feedstocks, to transport the fuel to distributors and to promote and sell the new products as well as create new engines or amendments to existing motors in order to make the new technology compatible with the machines they fuel. By 2010, France suggests that its proposed biofuel program will have led to 25,0000 additional jobs. The new ethanol blending mandate in Colombia has government officials hopeful that 170,000 new jobs will be added to the sugar ethanol industry in addition to a two to three fold increase in the average farming family income (WorldWatch, 2007, 124). Generally speaking, the promotion of any new reasonable technology to the public which includes promises of new employment opportunities is welcomed by society, thus further propelling the acceptance of earlier mentioned government implemented biofuel policies despite scientific research pointing to negative externalities of such energies.

V. Energy Security Incentives

The heavy reliance on the supply of fossil fuels throughout the twentieth century continuing to present day presents a series of dilemmas in regards to energy security and a sustainable fuel supply. If, as Lee Raymond noted, energy is indeed the very fuel of society, then the threat of an insecure energy supply would be a direct threat to society itself. The perceived scarcity of oil along with the instability of undemocratic oil exporting regimes has led to, and will continue to lead to, steep rises in the prices of traditional fossil fuel gasoline (Vaitheeswaran, 2005, 95). These rising costs in the fuel supply have proved to create a detrimental impact on the global economy as international oil trade is a major contributor to the flow of capital and has tremendous influence over global economic and political systems. Jose Goldemburg explains that maintaining energy security for many industrialized countries has come at high but usually hidden costs when examining aspects of military and security spending in attempts to alleviate disruptions in fuel supply which are coming from unstable, and at times volatile, regions of the world, most notably in the middle-east which contains over two-thirds of the worlds oil supply (Goldemburg, 2006, 8). In 2003, the US National Defense Council Foundation estimated that around $49.1 billion was required annually in order to defend the flow of Persian Gulf oil to importing countries, adding an additional $0.30 to consumers at the pump (WorldWatch, 2007, 110). Additionally, the economic growth and lifestyle changes in newly prosperous countries such as China and India will likely add to the pressure of increasing oil prices over the next decades as demand for such commodities also increases. This risk of fuel price volatility has pushed many governments to pursue a more diversified portfolio of energy supply in order to increase energy security and reduce the likelihood for future potential conflicts over fuel, and one such area of interest has been the development of biofuels.

The evidence presented suggests that government policies directed at the increased research and production of new biofuel technologies is linked to aspirations for a greater level of energy security with a more diverse fuel supply, agricultural and economic benefits, and the creation of new employment opportunities. There are, additionally, a number of unforeseen negative side-effects which have resulted from the production of biofuels and related government policies, especially those having environmentally damaging implications which would again indicate that these 'green' policies are not created to address environmental concerns. There are many distinct varieties of biofuels, produced from an array of substances in different regions of the world, so naturally the environmental implications therefore vary depending on the agricultural land use along with the choice of feedstock, processing, and management practices. In an article published by the OECD, it highlighted this concern of negative externalities noting that 'Indirect effects bring into question all current biofuel production pathways and many more of those that are being developed. Attention to these issues is vital if biofuels are to become a significant component of sustainable energy and socio-economic systems (Kammen, 2008, 48).'

VI. Negative Externalities of Biofuels

A. Environmental

Perhaps the most recent and widely publicized concern in regards to biofuel is one which was initially thought to have make biofuels more environmentally desirable in relation to fossil fuels, and that is the problem of dangerous emissions into the atmosphere. The original school of thought on biofuel was that although CO2 emissions are released when burned as fuel, just as traditional fossil fuels, the CO2 which is being released is the same CO2 which was extracted from the atmosphere by the feedstock during its plant life. Essentially, it was thought that these fuels were 'carbon neutral' as they both emitted but also consumed CO2 in a sort of recycling process, while fuel derived from coal or oil is extracted from underground and releases CO2 which has not been recently absorbed, and that is otherwise trapped. The main obstacle in this theory of carbon neutrality lies in the fact that large amounts of energy are needed to grow the crops, as well as process and transport them, and this energy often comes in the form of traditional fossil fuels (AEF, 2007, 1). Research on the total life-cycle estimation of emissions of biofuels varies widely from study to study and is far from conclusive, however there are patterns of consensus as to where the general problems lie with regards to emissions from biofuels.

One such area where scientists show concern about additional release of gases into the atmosphere is from the soil in which the feedstock plants are grown. Scientific studies have shown that the cultivation of crops is responsible for releasing a certain level of gas into the atmosphere. Scientists explain that more than twice the level of carbon in atmospheric CO2 can be found in decaying organic matter contained in soil, and that since these pools of carbon are so large, the preparation of soil for the farming of new feedstock can release much of this carbon into the atmosphere (WorldWatch, 2007, 172). As a result, these large releases of carbon from the soil can negate many emissions saved from the burning of biofuels for decades. The conversion of previously unused land into high scale agricultural production centers comes at a high initial loss of emissions from the soil. While this argument is not applicable for biofuels produced from land which was already under cultivation for crops for the purpose of food or animal feel, the change of land usage from food supply to fuel supply has negative implications all its own which will be addressed later. Due to policy making by governments throughout Europe, The United States and other industrialized nations in regards to biofuel requirements, which were discussed earlier, land is indeed being converted for such use in large scales, which is a source of controversy towards the promotion of biofuels.

One of the major causes of concern in regards to emissions and cultivation of biofuel crops is derived from the use of fertilizers which are further being utilized on great levels during the growth of feedstock. The concern with fertilizers being applied to crops in order to increase their usefulness is the high content of nitrogen in such substances. Nitrous Oxide, which is 296 times more powerful as a greenhouse gas than Carbon Dioxide, creates a great deal controversy in regards to atmospheric gases and climate change, and makes the biggest impact on the level of emissions from biofuels (Smith, 2007, 1). Scientists recently found that biofuels released twice as much Nitrous Oxide as previously thought, noting that three to five percent of the Nitrogen in fertilizer is converted and emitted into the air, leading Dr. Franz Conen of the University of Basil in Switzerland to describe the study as “an astonishing insight" (Smith, 2007, 1). Nitrogen Oxide is a precursor to ground-level ozone, more commonly known as smog, and can increase the likelihood of acid rain, which is what generates anxiety on the part of scientists and environmentalists alike. Typically, fertilizers which are produced are compromised of vast amounts of natural gas, which explains the associated levels of greenhouse gas emissions. In the United States, 98 percent of the corn crop is treated with synthetic Nitrogen fertilizers in order to achieve high yielding crops (WorldWatch, 2007, 28), and with the majority of ethanol production from the US being produced from corn feedstock, this can be seen as a major obstacle for the environmental sustainability of their production of biofuel. In relation to policy, the US senate is aiming to increase corn ethanol production sevenfold by 2022, which would result in an estimated 6 percent increase in greenhouse gas emissions from transport (Smith, 2007, 1). Due to much of this recent research unveiling the high risks of associated Nitrogen Oxide emissions, the use of fertilizers for the production of feedstock, and their resulting fuels, has become a point of contention.

A final source of emissions, beyond those which are released from the land during the growth of biofuel crops, causing concern is involved in the harvesting and transportation of feedstock and the final product of biofuel. The use of fossil fuels throughout the process of transforming feedstock into fuel greatly impacts the level of benefit in regards to the reduction of emissions, especially during the harvesting and transportation processes (Boyle, 2004, 412). The majority of the energy used to process biofuels in the US and Europe comes from fossil fuel, prominently diesel fuel, for the use of farm equipment such as tractors and trucks for cultivation, harvesting and transportation. Many milling facilities which convert the feedstock into usable material for fuel rely on coal and natural gas for heat, mechanical energy and electricity (WorldWatch, 2007, 165, 175). If great amounts of emissions are being released at the expense of traditional fossil fuels throughout the production process before biofuels are even put into the tanks of automobiles, one might question whether the emissions saved during combustion are valid. Furthermore, if environmental security and sustainability is truly the purpose of government initiatives with biofuel, if the previous evidence is true, perhaps the money producing these fuels might be better spent in alternative successful programs to reduce the level of emissions in the atmosphere

Emissions of the various forms of biofuels have been at the heart of scientific research in order to measure the success of new political policies. The majority of findings have shown that emissions from the burning of biofuels made from corn and rapeseed produce more greenhouse gases than they save when the entire life cycle of the fuel production is considered. These findings illustrate the importance of ensuring that procedures designed to reduce greenhouse gas emissions are thoroughly assessed before being hailed as a solution. Keith Smith, a professor at the University of Edinburgh and researcher, was quoted "One wants rational decisions rather than simply jumping on the bandwagon because superficially something appears to reduce emissions (Smith, 2007, 1)." Many of the efforts and methods for the production of biofuel have been suggested to be environmentally unsustainable by scientific studies, however as will be shown in a case study later, a level of success is possible in regards to the reduction of emissions within specific conditions and methods of biofuel production. As published by

WorldWatch, “the life-cycle greenhouse gas impact of energy crops ultimately depends upon what the crops are replacing. If they replace natural grasslands or forests, greenhouse gases will have increased; if on the other hand, energy crops are planted on unproductive land where conventional crops cannot grow, they have the potential to significantly reduce associated emissions (WorldWatch, 2007, 174).” The question then becomes how to discourage the replacement of forests and other natural carbon sinks in the face of government policy which rewards the production of feedstock in their place.

Emissions aside, other negative environmental externalities have been cited with the increasing mass production of biofuels. One such issue is with water, both in respects to the high level of water expenditure and the possible pollutants both resulting from production. Corn and soybeans, especially when produced across the western United States, require a great deal of irrigation in order to produce quality feedstock. Not only through irrigation, but also the process of washing plants and seeds for processing takes large amounts of water in order to prepare biofuels. Further complicating matters, corn requires more pesticides than other food crops and needs more fertilizer in order to produce high yields and achieve a good level of efficiency. Both of these factors inherently cause high levels of contamination in the ground water due to run-off from these chemicals, leading to a compromised water quality. As an example, according to writer Michael Pollan marine life within a 12,000 square mile radius has already been killed off in the Gulf of Mexico due to run-off entering the Mississippi from the corn belt in the United States (WorldWatch, 2007, 208). The issue of water supply and quality due to biofuel production is not isolated in the United States; the production of rapeseed in Europe results in similar issues of water supply as irrigation is essential there to the cropping of the feedstock. Concern has been expressed by experts at the World Water Week conference in Stockholm that growing food crops, which are being used for biofuel generation, could jeopardize water supplies (BBC, 2008, 1). This could pose the question as to where priorities should lie in regards to government legislation. Is a more diverse energy portfolio worth the damage which is done to global water supplies and marine life due to the necessary components of producing biofuels?

In relation to disturbing water supplies, there is also concern for the soil in which biofuel crops are being grown. "The history of every nation is eventually written in the way in which it cares for its soil," declared Franklin Roosevelt (Mann, 2008, 88). The capability of a nation to feed its people relies on the growth and import of staple foods, and the over-farming of land, which is taking place as a result of financial incentives to grow feedstock for the production of biofuel, strips soil of its many nutrients which is what produces nutrient rich foods for a human diet. More than 6 billion people rely on food grown on 11 percent of the land surface on earth (Mann, 2008, 92), and if the soil of this area is degraded due to excessive farming, crop yields on the same areas will fall due to soil exhaustion and the quality of food will decline, further resulting in food shortages around the world.

The other most publicized externality, and perhaps easier correlation to make based on evidence, which points a critical finger at biofuel is the problem of deforestation. The deforestation of numerous key parts of the globe tends to raise environmentally ethical questions in defense of societies of the future. The use of biomass in many developing countries, whether for small or large-scale industrial purposes, is leading to large-scale deforestation (Goldemberg, 2006, 5). Rising prices of feedstock crops and the need for the expansion of land space have made deforestation profitable, especially to those in developing countries in need of money with few other available options. Palm oil is a feedstock commonly used in the production of biofuel and is the most productive oil seed in the world. Due to these high yields, rainforests are being cut down in places such as Malaysia, Indonesia and Thailand in order to grow palm oil for American and European biodiesel production (Murphy, 2007, 1). Indonesia has the worst track record out of the three territories with land conversion for palm oil creating CO_2 debts which would require 423 years of emission savings through biofuels to pay off over the destruction of a natural carbon sink found in rainforests. Stephen Polasky of the University of Minnesota commented on the shortcomings of policies promoting biofuels noting "We don't have proper incentives in place because landowners are rewarded for producing palm oil and other products but not rewarded for carbon management. This creates incentives for excessive land clearing and can result in large increases in carbon emissions (Jha, 2008, 1)." This impact on the climate, according to experts, has been disastrous. According to Professor Siegert of Munich University, "We were able to prove that the making of these plantations and the burning of rainforests [in southeast Asia] and peat areas emits many thousand times as much CO_2 as we then are able to prevent by using palm oil, and this is a disastrous balance for the climate (Knight, 2007, 3)." In 1997, this burning associated with forest cleaning in Indonesia and Malaysia in order to make room for new farming was one of the single biggest contributors to greenhouse gas emissions (WorldWatch, 2007, 172). More recently, in addition to palm oil, soybean plantations have been the cause of deforestation in the Amazon as cattle farmers sell their land for the development of soybean farms and then relocate to new areas edging on the Amazon borders and leveling out new grazing pastures. Intensive agriculture grew in the Amazon region by 3.6 million hectares in 2001-2004, much of which has been attributed to the financial incentives of biofuel production (De Almeida, 2008, 165). Intrusion into the Amazon, in addition to emission spikes, has led to the endangerment of many species of animals, such as the orangutan which is now threatened with extinction (AEF, 2007, 1). In addition to the increasing food prices, the clear damages caused by first-world energy security solutions can be seen coming at the expense of the rest of the world in regards to environment. Dr. Rigelato, who is the chairman of the World Land Trust, noted that current policies could actually lead to more deforestation as countries outside of the EU were sought to meet growing demands for biofuels for use within the EU (BBC, 2008, 1). Malaysia and Indonesia, while rapidly expanding their palm oil acreage, have been hoping that the increased demand for European biodiesel in the next decade will enhance their exports by 30 percent or more (WorldWatch, 2007, 122).

B. Non-environmental

In addition to the negative environmental side-effects which have been caused or heightened by the rise in biofuel production, other non-environmental problems have surfaced as well. One such issue has been the production and exportation of other goods which use the same ingredients as biofuel. Corn, which is one of the most globally traded agriculture products, affects the production of many industries. Australia is one such country feeling the heat from rising prices and demand for corn, as well as wheat (Knight, 2008, 1). The expensive feed for their domestic livestock industry has greatly weakened its export position (WorldWatch, 2007, 113). With the numerous government policies creating higher requirements for bio-blend fuels, these increases are likely to continue. Similar to Australia, in the US a study determined that hog and poultry producers would also lose out as more corn, commonly used for feed, is diverted to the production of ethanol. Aside from meat and animal feed, increased demand for rapeseed oil in Europe has forced producers of margarine, mayonnaise and salad dressing to find alternative sources of ingredients (WorldWatch, 2007, 122). Therefore, while the common use of staple agricultural products is increasing the value of these items for farmers and creating economic growth for agriculture as a whole, it puts strain on many of the meat markets and other exports around the world which are tied to biofuel related components.

In relationship to the rising prices of staple foods and the increase in cost of production of many other foods, not only is this a problem for producers in the food market but for consumers of food worldwide, which includes everyone on the planet. In many areas where a surplus of agricultural land does not exist, biofuels create a competition between local needs for energy and local needs for food (Boyle, 2004, 144). Keith Wiebe, the service chief in the Economic and Social Development Department at the Food and Agriculture Organization of the United Nations, is currently working on an annual report on the state of food, which this year is focusing on biofuels. He ascertains that biofuels, while not the only factor, are obviously playing a part in the current food situation which has led to the increase in commodities prices and is having an adverse effect on the poor consumers of the world, particularly in the developing countries (Knight, 2008, 1). A Haitian diet is heavily reliant on rice, at approximately 20 percent of their total diet, creating a large demand for the import of this staple food. The price of

“Miami rice” from the United States has doubled due to increased value of agricultural land and feedstock crops, creating a severe food security issue for the islanders (Bourne, 2008, 110). The Department for Business Enterprise & Regulatory Reform in the UK has also acknowledged this issue, stating in a consultation document of the UK Renewables Program, “We recognise that increasing the production of biomass energy crops has the potential to lead to competition with food crops for land and so to increased food prices. To a limited extent, recent commodity price rises are due to an expansion in the production of biofuels, but other factors have together made a greater contribution, (BERR, 2008, 188).” A report released by the Aviation Environment Federation called it ‘morally repugnant’ to take over space for the growth of energy crops which is needed for the production of crops for food in poor countries. An African campaigner blatantly declared, “We are taking away food from poor people’s tables and putting it into rich people’s cars (AEF, 2007, 1).” The rising cost of meat due to the use of typical animal feed for biofuels, as well as the overtaking of agricultural space once used for the farming of animals, has made the high valued meats and dairy all but impossible to buy for those consumers in net food importing countries who are already suffering in impoverished areas. Additionally, while creating life and death food security issues for many of the world’s poorest regions, it also changes the consumption patterns of a large group of people by making a diet filled with nutrient rich meats and dairy particularly expensive and unsustainable. The biofuel policies and directives enacted by governments, evidence suggests, continue to create agricultural economic prosperity while alienating and creating hardship for worldwide consumers in the food market. This side-effect in biofuel production is undoubtedly an ethically driven argument showing opposition throughout dialogue on the mass production of energy crops.

There are arguments which contest this idea of competition for food. David Blume, author of Alcohol Can Be a Gas, ascertains that this externality of limited agricultural space and can be completely avoided. He states that, “Rest assured, there is enough land to produce solar energy in many forms, including alcohol….shifting totally away from traditional industrial farming methods and implementing sustainable practices, ethanol is an excellent option to solve our energy problems (Blume, 2007, 24).” Blume notes in his writings that success has been found in other countries, such as Brazil which will be discussed later, and that these same successes can be replicated around the world. He sites that alcohol production can be energy efficient with the example of a study conducted by Isaias de Carvalho Macedo of Brazil which shows an energy output of more than eight units for every unit of input (Blume, 2007, 25). What Blume doesn’t note is that this study, and Brazil’s entire alcohol program, is run with a feedstock of sugarcane. Sugarcane is thus far proven to be the most energy efficient crop for alcohol production with its high level of sugar content. As sugarcane cannot be grown in most regions of the world, such as North America or Europe, due to climatic conditions, this study does not provide a feasible global solution.

For the case of the United States, Blume argues that corn is not the answer to produce alcohol used for fuel due to its low level of alcohol production per bushel, but that other crops may be grown in the United States which have higher efficiency levels and take up limited agricultural space. Blume’s primary solution relies on Cattails. Blume explains that Cattails, which typically grow in marshy areas, can be the solution to nearly all fuel stocks in the United States. He writes, “At 10,000 gallons per acre [ethanol], we’d only need about 6367 acres per U.S. county… to replace our entire 200-million-gallon fuel demands. That amounts to only 1.46% of our agricultural land. (Blume, 2007, 129).” This small percentage of space is not specific to farmland, but is categorized in agricultural land which can include natural sinks such as forests, lakes, and any spaced labeled as agricultural by the government. As noted earlier, the change in land usage from forest to crops, considering carbon released in soil preparation and loss of a natural carbon sink, creates a greater CO2 deficiency than can be gained by the use of biofuels for a period of 100 years. Blume, however, also offers an interesting solution which notes that “If each county were to convert only 1000 miles of county-maintained roadsides to that a five-foot-wide strip of cattails was cultivated on each side of the road, boom mowers could shred and harvest up to three crops a year…and in theory produce 61 billion gallons of fuel without using a single acre of farmland (Blume, 2007, 128).”

I find three main concerns which could arguably negate Blume’s solution, climate and conditions, health and ecological concerns. As Blume noted earlier, cattails grow in marshy wet conditions, which do not naturally exist is many counties and roadsides around the United States. Secondly, the tiny seeds of cattail are attached to fluffy down which is easily carried in the wind. Cattails also contain pollen. If we were to introduce a large scale cattail production along our roadways, this could present to be a health disaster with uncontrollable growth due to the ease of spread. Any large scale change in plant growth of an area should be cautioned due to possible ecological side effects, such as bugs which feed on the cattails and the plants which would be competing for water and nutrients in surrounding areas due to the ease of spread. Would this great increase in insects along roadsides spread disease to the travelers who frequent those paths? Would these insects which feed on the cattails then need to be sprayed with chemicals, which would require more fuel in "industrial like farming" which Blume warned about? There are a great number of externalities which exist in Blume's theory which are not mentioned or addressed in his book making the solution inadequately researched and inapplicable as it currently stands.

Overall, the extent of the numerous externalities involved in the production and consumption of biofuels further asserts the notion of a non-environmentally focused policy by the industrialized world being driven primarily by aspirations of energy security and market incentives. There is however the possibility of having a level of economic benefits associated with biofuels while also minimizing the negative side-effects discussed in this article. As noted earlier, the efficiency and impact of biofuels relates specifically to the method of production including the choice and growth of feedstock, the use of energy during processing and the implementation for use. Below is a case study of a biofuel production program which seems to have mastered better than any other method the best components and levels of all above mentioned categories, and while not perfect has resulted in the best case scenario thus far for any possible future of biofuels.

VII. Case Study – Brazil

Brazil’s Pro-Alcohol program is the world’s largest commercial biomass system, established in 1975 when oil prices were high in attempts to mitigate the macroeconomic impacts of oil price instability. For the first 25 years, the estimated savings on foreign fuel imports were in the range of $40 billion (Boyle, 2004, 135). The Pro-Alcohol program includes the production of ethanol for the use of fuel and is recognized as the cheapest in the world in today’s market, lending the program the highest level of competitiveness due to its choice of feedstock.

Supplying over 40 percent of all fuel ethanol worldwide, sugar cane is the most substantial crop for the production of biofuels as of yet (WorldWatch, 2007, 25). Coupled with large areas of agricultural land available for cultivation, Brazil, namely in the center-south region, has the highest level of sugar cane production in the world with a high sugar concentration which can be retrieved for energy and a low level of agricultural maintenance in regards to irrigation (De Almeida, 2008, 161), which displaces many of the concerns in regards to water quality as a result of production. In a CNN report, an economist explained that “Brazilian sugar cane is the classic example of a type of biofuel that is now performing efficiently and competitively, alone among all the major biofuel foodstocks in being competitive at market prices. Whereas in the U.S., maize [corn] continues to cost more to produce it than it does to be competitive with the fossil fuel counterpart (Knight, 2008, 2).” The cost of producing ethanol from sugar cane in Brazil is approximately half of that needed from grain in Europe, allowing the country to compete with fossil fuels at a competitive price of approximately $42 per barrel (De Almeida, 2008, 159). The result has been that Brazil, while meeting its own domestic needs, is the world's largest exporter of ethanol fuel compromising of 50 percent of its total sugarcane production (WorldWatch, 2007, 11).

When examining the efficiency of the ethanol biofuels derived from sugar cane coming out of Brazil, the figures above which show the level of exportation and money saved on the import of fossil fuel oils is an excellent beginning in the economics of sugar cane ethanol. Janet Sawin proposed that 'the goal must not be to simply install capacity, but to provide the conditions for creation of a sustained and profitable industry, which, in turn, will result in increased renewable energy capacity and generation, and will drive down costs (Sawin, 2006, 71)', and this is precisely what the Brazilians have been able to accomplish better than anyone else in the market. In part, much of their efficiency in relation to their ethanol fuel is due to inherent agricultural advantages of a high sugar level energy crop which is easily sustainable and produced. However, a long-term investment in their program has aided to alleviate many of the other problems that biofuel productions often have or create. For example, in regards to productivity, the average ethanol yield in the State of Sao Paulo per hectare from 1977 to 2003 increased from 66 tons to 80 tons (De Almeida, 2008, 157), therefore greatly increasing their yield and profits by almost 25 percent thus far throughout the program through greater efficiency. One of the biggest breakthroughs in efficiency is arguably the 2003 introduction by the auto industry of so-called flexible-fuel vehicles, or FFVs, which have the flexibility to run on any combination of gasoline or ethanol, allowing the consumer the freedom to choose whichever is cheaper (WorldWatch, 2007, 6). Currently, ethanol is sold at a lower price throughout the country, resulting in a full-scale market for biofuel.

When examining environmental efficiency, these Brazilian biofuels produced from sugar cane are the best case scenario thus far in the industry for environmentalists and politicians alike. It is estimated that the total life-cycle greenhouse gas emissions reductions in regards to Brazil's ethanol biofuel are approximately 46.6 million tons each year, or 20 percent of Brazil's annual fossil fuel emissions. This is due to the high levels of sugar residing in sugar cane, the lack of a need for irrigation, and to the low levels of fertilizer utilized due to high soil productivity (WorldWatch, 2007, 179), all of which aid in mitigating many of the environmental concerns discussed earlier. It is important to note, however, that the pre-harvest burning of sugar cane straw has been common practice to increase yields in the past, resulting in the majority of all emissions from the entire life-cycle of the fuel. This is a tradition which is quickly being phased out by urging from government officials and a new policy enacted in 1998 and 2002 (WorldWatch, 2007, 211). The most impressive element which provides the Brazilian program with its greatest reduction in emissions is the use of 'bagasse' for energy supply in the farming equipment during the processing and harvesting of the sugar cane. By using a byproduct leftover from the production process, it eliminates a large percentage of need for fossil fuels during creation of the ethanol. It is now estimated that ethanol fuel from Brazil can cut emissions by over 80 percent (De Almeida, 2008, 164), making it the most environmentally viable alternative to fossil fuels.

While the Brazil Pro-Alcohol program has proved to be a great success thus far in the areas of innovation and further perfection of the process of ethanol production leading to greater economic, agricultural and environmental efficiency, there are concerns for the future. In order to further expand the cultivation of sugar cane in Brazil for biofuel, the country now faces tough decisions. The Cerrado, an uncultivated, biologically diverse area, remains the largest area worldwide left for expanding sugar cane plantations. Scientists argue that such an expansion would come at a great ecological expense as it is home to over 900 species of birds and 300 mammals, most of which are threatened or endangered (WorldWatch, 2007, 37). It is in the expansion of their program that Brazil faces its greatest challenge; the prospect of further economic prosperity versus the preservation of ecologically precious domestic landscapes. As examined earlier, the negative effects created with deforestation and massive changes in soil use have some of the greatest pronounced impacts on the environment in regards to global climate change, therefore Brazil's program could take a drastic turn depending on developments in the near future. As the program lies now, however, Brazil stands as a global leader in the field of new developments and technology for a world less dependent on fossil fuels. Their success as an environmentally sustainable alternative to fossil fuels is a triumph for the field of biofuels, however given the specific conditions needed to create this successful program, growth of highly productive sugar cane, specific climate with no need for irrigation and land space already being used for the crops growth negating the need for land use change, the Brazil Pro Alcohol Program is a regional solution which could not be replicated on a global scale. Furthermore, any expansion in production sought in order to meet growing global demands in ethanol fuel would require deforestation of the Amazon, which would compromise the program and its successes above the others.

VIII. Conclusion

The attempt to alleviate threats posed by energy security and create new economically prosperous opportunities with biofuels on a global scale has thus far proved to be unsustainable and will continue to pose other worldwide problems through their production. In the future, creating an energy supply that efficiently drives domestic economy, while keeping itself sustainable and within respectable frames of the environment will be essential in order to make the move from traditional oil and fossil fuels. A specific prescription provided by Sawin advises that "For renewable energy to make a significant contribution to economic development, job creation, reduced oil dependency and lower greenhouse gas emissions, it will be essential to improve the efficiency of technologies, reduce their costs and develop mature, self-sustaining industries to manufacture, install and maintain renewable energy systems (Sawin, 2006, 71)," and mass global production of biofuels has fallen short of meeting these demands. It is argued that thus far biofuel production programs throughout most of the world, notably Europe and the United States, these necessary components are found to be lacking. While the policies and developments are narrowly focused on energy security and diversity of supply, the environment has proved to become a clear loser in the equation. In order for biofuels to ever truly compete with other existing energy sources, all of these factors must inclusive in the total life-cycle production of the product, which thus far is easier said than done and perhaps a bit implausible given the crops and climates currently available in regions attempting to create biofuel.

Until further progress is made in the production process for biofuel, alternative renewable energy methods appear more environmentally desirable. Both the U.S. and China are making new large investments into wind energy, already utilized on large scales in other countries around the globe. The U.S. has taken its largest investment in clean renewable energy in history this year awaiting final approval on a 4.9 billion dollar plan to invest in transmission lines to carry wind power across the Texas plains. China, which was recorded as having the largest level of carbon emissions last year, is also putting a great deal of resources into wind energy, with approving remarks from Steve Sawyer of the Global Wind Energy Council describing the program as "huge" (Busari, 2008, 1). It is important, however, to recognize the success of the ethanol production in Brazil, however as noted earlier, the replication of this program in other areas of the world are unlikely given the specific advantageous conditions of the Brazilian region which have allowed their success. In sum, given the technologies and conditions of present day in regards to the global production of biofuel, as well as taking into account ventures into alternative clean sources of energy such as wind, while biofuel may have initially been hailed as one of the energy security solutions of the industrialized world, it is rapidly becoming a multifaceted security threat for the whole world making these alternative options more desirable.

Bibliography

Aviation Environment Federation. (2007) Biofuels No Answer to Aviation Emissions. Retrieved on June 4, 2008, from http://www.aef.org.uk/?p=152

BBC News. (2008) EU Biofuel Policy is a 'Mistake'. Retrieved on June 3, 2008, from http://news.bbc.co.uk/1/hi/sci/tech/6949861.stm

Blume, David. (2007) Alcohol Can Be a Gas. Retrieved on Oct. 29, 2008, from http://www.alcoholcanbeagas.com/book_menu/360/277/329/383/425

Bourne, Joel K. Jr. (2008) Dirt Poor. *National Geographic.* 214:3 pp. 108-111

Boyle, Godfrey (ed.). (2004) Renewable Energy: Power for a Sustainable Future. Oxford: Oxford University Press.

Bozbas, Kahraman. (2008) Biodiesel as an Alternative Motor Fuel: Production and Policies in the European Union. *Renewable and Sustainable Energy Reviews.* 12: 542-552.

Busari, Stephanie. (2008) U.S., China lead the way in tapping wind power. CNN Retrieved on July 28, 2008, from www.cnn.com/2008/TECH/science/07/28/wind.energy/index.htm

Cannon, M.F. & Welch, M.J. (2003) Gas Turbines and Renewable Fuels – the Technologies, the Risks, and the Rewards. in IMechE. Renewable Bioenergy – Technologies, Risks, and Rewards. London: Professional Engineering Publishing Ltd.

De Almeida, Edmar Fagundes; Bomtempo, Jose Vitor & De Souza E Silva, Carla Maria. (2008) The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis. *Energy*. 7: 190-239.

Department for Business Enterprise & Regulatory Reform. (2008) Renewable Energy Strategy Consultation: Chapter 7 – Bioenergy. Retrieved on Sept. 4, 2008, from http://renewableconsultation.berr.gov.uk/consultation/chapter-7/executive-summary/

Environmental Protection Agency. (2008) Renewable Fuel Standard Program. Retrieved on Sept. 4, 2008, from http://www.epa.gov/OMS/renewablefuels/.

European Commission. (2003) European Biofuels Directive. Retrieved on Sept. 4, 2008, from http://ec.europa.eu/energy/res/legislation/doc/biofuels/en_final.pdf

Goldemberg, Jose. (2006) The Case for Renewable Energies. in Assmann, Dirk; Laumanns, Ulrich & Uh, Dieter. (eds). Renewable Energy: A Global Review of Technologies, Policies and Markets. London; Sterling, VA: Earthscan

Hake, Jurgen-Friedrich & Eich, Regina. (2006) Energy and Sustainable Development. in Dooley, Brendan (ed). Energy and Culture: Perspectives on the Power to Work. Hampshire, UK; Burlington, VT.: Ashgate Publishing Limited.

Jha, Alok. (2008) Biofuel Farms Make CO2 Emissions Worse. *The Guardian.* Retrieved on June 3, 2008, from http://www.guardian.co.uk/science/2008/feb/08/scienceofclimatechange.biofuels

Kammen, Daniel M.; Farrell, Alexander E.; Plevin, Richard R.; Jones, Andrew D.; Delucchi, Mark A. & Nemet, Gregory F. (2008) Energy and Greenhouse Impacts of Biofuels: A Framework for Analysis. *Energy.* 7: 45-90.

Knight, Matthew. (2008) Biofuels: What do the Experts Think? Retrieved on June 4, 2008, from http://edition.cnn.com/2008/TECH/science/05/30/Biofuels.opinion/index.html.

Mann, Charles C. (2008) Our Good Earth. *National Geographic.* 214:3 pp. 80-107

Murphy, Meghan. (2007) Sustainable Biodiesel: The Ecological Cost of Fuel. Retrieved on June 4, 2008, from http://www.renewableenergyworld.com/rea/news/story?id=47421

Sawin, Janet. (2006) National Policy Instruments: Policy Lessons for the Advancement and Diffusion of Renewable Energy Technologies around the World. in Assmann, Dirk; Laumanns, Ulrich & Uh, Dieter. (eds). Renewable Energy: A Global Review of Technologies, Policies and Markets. London; Sterling, VA: Earthscan

Shanahan, G. (2003) Government Policy and Support for Bioenergy. in IMechE. Renewable Bioenergy – Technologies, Risks, and Rewards. London: Professional Engineering Publishing Ltd.

Simpson, P. (2003) Supply Chain Development for Biomass Fuel – Challenges and Opportunities. in IMechE. Renewable Bioenergy – Technologies, Risks, and Rewards. London: Professional Engineering Publishing Ltd.

Smith, Lewis. (2007) Rapeseed Biofuel 'Produces More Greenhouse Gas than Oil or Petrol.' *Times Online*. Retrieved on June 4, 2008, from http://www.timesonline.co.uk/tol/news/uk/science/article2507851.ece

Vaitheeswaran, Vijay V. (2005) Power to the People: How the Coming Energy Revolution Will Transform an Industry, Change Our Lives, and Maybe Even Save the Planet. London: Earthscan

Worldwatch Institute. (2007) Biofuels for Transport: Global Potential and Implications for Sustainable Energy and Agriculture. London: Earthscan