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Spring 2011
SIS, Global Environmental Policy
Capstone for University Honors
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Battle over Biofuels: The road to a sustainable U.S. ethanol industry by reducing and redefining government intervention

Abstract

This paper examines the politics of ethanol in the United States, and opportunities for reform and improvement. In the decades since its birth, the industry has seen a high level of support and intervention from federal and state governmental policies, including subsidies, mandated levels of production and consumption, and import tariffs. These policies have shaped ethanol in the United States such that certain technologies and business strategies have benefited while others suffered. This trend, though, while it has been good for the business of ethanol production, has been counterproductive in reaching the stated goals of the ethanol industry. Higher levels of ethanol production were supposed to help wean the United States from foreign sources of energy, provide jobs, and offer environmental benefits. None of these benefits have truly come to pass. In part, this is because corn has become the privileged feedstock for United States ethanol production. Conversely, more advanced forms of biofuels that are obtained from cellulosic plant sources have greater potential to solve our environmental and economic problems, but have been largely left out of our national support system. To foster growth and development of a sustainable transportation fuel industry in the United States, government support must be refocused from subsidization to infrastructural investment. Programs that will expand the capacity of sustainable biofuels to replace corn-based ethanol and meet the majority of our energy demands must be the future of government involvement, rather than the conventional subsidy practices of the past.

"No one would remember the Good Samaritan if he'd only had good intentions; he had money as well."

-Margaret Thatcher, January 1980

Introduction

Environmentalists have long labored to convince the human race to do the right thing, invoking the higher power of nature and threats to mankind and the environment, to affect positive change. More recently, however, many have begun to realize that simply 'doing the right thing' is not enough of a motivator. In the past decade or so, environmentalists have started to invoke a much more powerful motivator, arguably the strongest of them all: money. Making the right thing to do the *profitable* thing to do is now a common strategy. For centuries, changes have been accomplished along economic lines, and the environmental movement is slowly adapting to this far more pragmatic and capitalistic orientation.

It is no surprise then that the battle over energy, one of the most daunting and important challenges of our time, is deeply rooted in economic terms. As countries struggle to reach agreements on climate change and governments attempt to foster cleaner solutions for their energy futures, the number one issue they grapple with is economic growth. Growth is not always at odds with a clean energy future or demanding protection from policy changes. It is also used as a tool for implementing the changes themselves. In this crucial and controversial debate over how to fuel our civilization, doing the right thing has become complicated, and tradeoffs make simple solutions hard to come by.

The question of ethanol is no exception to this trend. To create energy independence and curb the effects of climate change with alternative sources of fuel, those fuels must be profitable, or at least economically viable. If doing the right thing is to last and have the desired change, it must have financial backing.

Ethanol has been a contentious and important issue since its introduction. The triple threat of food security, climate change, and peak oil make the biofuel debate a crucial element in political and economic discussions. As science solidifies over the causes and effects of anthropogenic climate change, solutions must be found to power our economy in ways that do not increase the level of CO_2 in the atmosphere. Simultaneously, the steady decline of fossil fuels demonstrates an even more obvious need for new fuel sources. And as industrialization of agriculture continues to reach only modest successes in the fight against global hunger, using food sources to create conventional ethanol is an increasing point of contention.

With all of these pressures demanding new ways of creating energy, ethanol would seem an obvious choice, and common sense would lead us to invest heavily into such a promising solution. However, in its current form, the ethanol industry is not such a simple solution to our problems. Many have argued that this technology exacerbates climate change and fossil fuel dependence, rather than helping combat them. Questions of sustainability, land use, and a wide variety of other consequences have cast serious doubt over the feasibility of ethanol. In the United States, this tug-of-war is primarily centered on the government's support of the industry, mainly through subsidies. Subsidizing ethanol has driven the industry's growth and shaped its character. Since many have questioned the nature of ethanol and its role in

combating climate change, these subsidies have also come under intense scrutiny. The government has selected, both intentionally and accidentally, the aspects of the industry that are best suited for immediate growth and development. As a consequence, the outlook of ethanol in the United States has less to do with solving environmental issues, and more to do with driving profits. By honestly evaluating the governmental policies that define the current state of ethanol in the U.S., we can better understand what a truly sustainable system would look like.

Changing the ethanol subsidies system is a daunting, but essential, task. These policies are deeply entrenched in American politics in a variety of areas, including agriculture, energy, and transportation. Removing the market distortions that have defined the ethanol industry would foster the kind of progress that is essential for combating climate change and energy independence concerns, and would also provide a template for improving subsidy policies in other industries. An honest discussion about the effects of government intervention can be facilitated by reviewing a successful story of the biofuels market. However, while money is a powerful motivator, and can be used to create positive change, it is also a dangerous tool. To ensure that ethanol policy is not counterproductive, the incentives of capitalism have to be matched with the incentives of common sense.

It is important to keep in mind that monetary government support it is not an inherently evil force. To adequately transition to a clean energy economy, public investment is crucial to give technologies like ethanol a chance to compete with the advantages that fossil fuels' long history has afforded it. This paper does not seek to propose complete independence and autonomy for the U.S. ethanol industry.

Instead, it will explore ways of redistributing current resources to better reflect the imperatives and long-term goals of this fuel source.

PART 1: The History of U.S. Ethanol

Introduction

To evaluate the current state of ethanol in the United States, it is imperative to look at its history of growth and development, particularly through a review of its subsidy programs and legislative actions. By analyzing the financial incentives that have fueled the industry's progress, we can better understand why certain aspects of the industry have been favored over others. The regulatory and legislative structure that supports the industry is complex, and lacks cohesion. For more than 30 years, a host of overlapping and continuously changing subsidies have been implemented, and rarely are measures taken to create broad, systemic changes. As a result, unintended consequences are common, and good intentions are often at the mercy of short-term goals and deliverables. This section reviews the programs that have been implemented, evaluates the current state of political incentives, and describes the technologies and business strategies that make up the industry. It will soon become apparent that the complex nature of U.S. ethanol, both inside and outside government, is a primary motivation for reevaluating the efficacy of governmental intervention.

Summary of past subsidy programs and legislation

Ethanol subsidies in the United States began in 1978 with the Energy Tax Act, a statute of the National Energy Act, which was drafted partly in response to the 1973 oil crisis. The act established a subsidy for ethanol at 4 cents per gallon of

blended fuel (10% ethanol, 90% gasoline), which was an equivalent of 40 cents per gallon of pure ethanol (Tyner). The subsidy provided an exemption for ethanol blends from the gasoline excise tax. Until 2004, all ethanol subsidies were enacted on this basis, providing a fluctuating exemption on the excise tax (Koplow). Through provisions in the Surface Transportation Assistance Act of 1983, the Tax Reform Acts of 1984 and 1986, the Energy Policy Act of 1992, and other pieces of legislation, the ethanol exemption grew from 40 to a peak of 60 cents per gallon, before falling to 51 cents in 2005 (Tyner). Throughout this period, the subsidization of ethanol was based on providing an exemption to the gasoline excise tax. In 2004, The Jobs Creation Act established the Volumetric Ethanol Excise Tax Credit (VEETC), which modified the implementation procedure of the subsidy. The VEETC was an attempt to detach the ethanol subsidy from the excise tax, as well as package together 4 separate policies into one subsidy program. It includes a 45 cent per gallon tax credit (rather than exemption), a 54 cent per gallon tariff on imported ethanol, a $1.01 per gallon tax credit for cellulosic ethanol, and an additional 10 cent per gallon credit for small producers (Abbott).

On a national level, the subsidization of ethanol in the United States has been largely based on these two programs, the original excise tax exemption, and the current VEETC. However, many other policies and programs have contributed to the overall system. Government support can take many forms beyond tax rebates, and many of these have been applied to the ethanol industry. The Energy Security Act of 1980 created federally insured loans for ethanol producers, which allowed investment to be made more freely and easily (Koplow). Further tax exemptions

have also been issued for blends of higher ethanol content, incentivizing larger incorporation of ethanol into the fuel market. Before their incorporation into the VEETC in 2004, tariffs on imported ethanol were always a separate but equally powerful form of support for the domestic industry. These tariffs have fluctuated between 50 and 60 cents per gallon, largely affecting imports of sugarcane-based ethanol from Brazil, which is the leading producer outside of the United States. These import tariffs "have been effective in protecting the ethanol industry and keeping domestic prices strong" according to one study (Elobeid).

In addition to traditional tax exemptions or rebates, special loans and bonds, and import tariffs, there are other initiatives and policies that have helped the ethanol industry. The Clean Air Act, for example, mandated an improvement on the makeup of gasoline to help curb pollutants in the atmosphere. The first response to this mandate - the addition of the compound methyl tertiary-butyl ether (MTBE) - was later deemed to be a cancer-causing agent, so ethanol became an alternative solution to address this issue. In 1988, The Alternative Motor Fuels Act allowed automakers to receive credits for manufacturing cars that ran on alternative fuel sources. Higher efficiency standards for automobiles, such as the CAFE standards, also favored an increase in ethanol blends in gasoline, further bolstering the industry (Tyner). It is important to distinguish these measures as examples of government support for the consumption, rather than the production, of ethanol. While tax rebates for producers and special loans provide examples of policies that affect the supply of ethanol, policies like the Clean Air Act and the import tariff systems are designed to influence demand within the United States.

Since the 1980's, states have joined the federal government in providing subsidies and other incentives for the ethanol industry. As of 2006, 28 states had at least one financial incentive in place for ethanol (Koplow). These programs often augment, overlap with, or even interfere with federal programs, causing a complex and confusing web of government support of ethanol. Many researchers have noted that even identifying the full number and scope of state level subsidies to ethanol is nearly impossible, because either the data is inaccessible, or the impacts of policies are indirect and difficult to track.

Review of current political landscape

The primary driver of current ethanol production and policy in the United States is the Renewable Fuel Standard (RFS). First created in the 2005 Energy Policy Act, the RFS essentially sets an annual goal for ethanol production. The RFS reflects a common theme within the overall ethanol policy in the United States: goals are based upon simple growth of the industry, with little concern or attention for the environmental or social implications of this growth. The EPAct of 2005 set the goal at 7.5 billion gallons annually by 2012, and the 2007 Energy Independence and Security Act (EISA) augmented this goal to 9 billion gallons per year, growing to 36 billion annually by 2022.

Notably different from previous legislation, the EISA distinguishes between corn and cellulosic ethanol, by requiring that at least 21 of the 36 billion annual gallons of ethanol in 2022 must be "advanced biofuels", while corn ethanol contribution must not exceed 15 billion gallons (Alvarez). To qualify as advanced, the ethanol must contribute 50% less greenhouse gas emissions than corn ethanol,

based on a life-cycle analysis, a distinction that is crucial to the evaluation of biofuel sustainability. The distinction between cellulosic and corn sources in the EISA is a positive step forward in paying heed to concerns over sustainability. However, assigning arbitrary numbers does not go far enough towards ensuring that growth of the industry results in a positive environmental outcome.

To support the consistent growth that the Renewable Fuel Standard demands, the federal government relies on the VEETC's 4-part system to keep prices low enough to compete with crude oil and Brazilian ethanol. This program has been a major focus of American energy politics in the past decade; in 2007 75% of all federal funds for renewable energy development went to the VEETC. The Baker Institute estimates that in 2008, the average cost to taxpayers for ethanol subsidies amounted to the equivalent of an extra $1.95 per gallon (Alvarez). Currently, although one of its four parts is an augmented subsidy for cellulosic producers, the vast majority of funds are allocated to corn ethanol, mostly to producers in the nation's corn belt.

In response to growing concerns and complaints over the negative impacts of corn ethanol, recent trends have been moving towards diversifying the industry. In an effort to appease the scientific community in regards to the debate between first generation (corn) and second generation (cellulose) biofuels, President Obama included an allocation of funds for research and development in the 2009 stimulus bill. Nearly $500 million was given to fund research and development in advanced biofuels, and to help build demonstration-scale refineries (Alvarez). In March of this year, Senator Dianne Feinstein (D-CA) introduced a bill along with Senator Jim

Webb (D-VA) that aims to eliminate the 45 cents per gallon tax credit to ethanol blenders that is the central pillar of the VEETC. She argued that "Ethanol is the only industry that benefits from a triple crown of government intervention: its use is mandated by law, it is protected by tariffs, and companies are paid by the federal government to use it. It's time we end this practice once and for all." (CVBT). The bill would preserve the 45 cents per gallon subsidy for advanced biofuels, and mandate that the import tariff on foreign ethanol be reduced to match that same subsidy level. She argues that reducing the tariff while maintaining advanced biofuel subsidies would avoid further dependence on imported oil while supporting the development of sustainable ethanol practices domestically. Senator Feinstein's perspective marks an important contrarian discourse in the current American political scene over government support for ethanol. Nonetheless, the status quo has not been significantly changed, and the government continues to provide serious financial support to the corn ethanol industry.

Evaluation of the current ethanol industry

At its most basic level, ethanol is a liquid fuel derived from fermentation of a starchy substance. Different manufacturing processes use different sources for their distillation process, which yield different results. In Brazil, for example, the primary source, or feedstock, is sugarcane. In the United States, the majority of ethanol is derived from corn, with very little input from other sources. It is important to distinguish between the two main types of biofuels, titled first generation and second generation. First generation feedstocks, such as corn, are substantially easier to use for the production of ethanol, because they can be fermented and distilled

directly from their starch content. Second generation sources, which include cellulosic materials like switchgrass, are more complex and involve the use of enzymes to obtain the energy content necessary for ethanol production (Hunt, *Biofuels for Transportation*). As a result of this discrepancy, the most cost effective process for ethanol production comes from first generation sources, while the more technologically demanding and intricate process involved with cellulosic stocks proves to be less profitable in the short term.

After ethanol is produced, it must be blended with traditional gasoline to be used in automobile engines. Most of the distribution centers or retailers where ethanol is blended with gasoline are in the coastal regions of the United States. Since the majority of ethanol refineries are located in the Midwest, where the most corn is grown, transportation of ethanol is a major limit to its continued growth. Unlike petroleum, which is largely transported over pipelines in the United States, no such networks exist for ethanol, which must rely on truck, rail or barge transportation. These modes tend to be more expensive and less efficient, causing the industry to be handicapped in comparison to the oil industry (Alvarez).

In 2007, the United States produced a total of 6.5 billion gallons of ethanol, which is close to the desired levels created in the Renewable Fuels Standard. However, as previously noted, a great deal of ethanol is used simply to replace MBTE, an additive that oxygenates all gasoline. Therefore, the amount of ethanol that actually displaces gasoline consumption is much smaller. The Baker Institute estimates that only 278,000 barrels per day of the average production levels currently seen in the United States are actually displacing gasoline. When compared

with the daily U.S. demand for gasoline, estimated at 9 million barrels, it is clear that this industry is still only a small player in the transportation fuel makeup of the country as a whole (Alvarez). Nonetheless, this small percentage still reflects a major rise within the industry in the last few years. In 2006, the full capacity was at 3.2 billion gallons, approximately one-half the capacity of 2007, only a year later.

Globally, ethanol has seen just as dramatic a rise in the past few decades. World production nearly tripled from 5.5 billion gallons in 2000 to 14 billion in 2007. The EU has begun importing a significant portion of the world ethanol production, which comes mainly from Brazil. Although the United States is the second largest producer, a relatively insignificant amount of our ethanol is exported overseas (Brigezu). The two global political issues that are most relevant to ethanol for the United States are food aid and free trade. One of the most common complaints against increases in ethanol production in the U.S. is that it sacrifices food sources for fuel. Although ethanol advocates vehemently deny that ethanol production contributes to global food scarcity, many have claimed that the U.S. is contributing less to hungry nations as a result of its biofuels policies. Secondly, since the Brazilian ethanol market is the only major competitor with the United States' domestic industry, the tariff system comes into conflict with free trade issues and NAFTA principles. If the government continues to protect the domestic ethanol industry, it will eventually face international pressures and a more strained relationship with Brazil.

The rapid growth of ethanol globally and within the United States is attracting so much attention that it is beginning to appear unstoppable. Since few

new industries ever see such quick increases in capacity and capital accumulation, investment in conventional ethanol is very high. Many banks are willing to lend manufacturers up to 70% percent of the upfront cost of building a new ethanol plant, a rate that is unheard of for projects of that size and scope (Koplow). Additionally, some have argued that the health of the industry is not as dependent on government support as it appears on the surface. Whereas crude oil prices often rise unpredictably, demand for alternative fuels remains steady and consistently growing. Tyner argues that if the crude oil price were to stay well above $100 per barrel at a consistent pace, the industry could remain profitable without any support from the government. However, these predictions are difficult, because the price premium for ethanol over gasoline also depends on the price of corn, which is itself highly influenced by crude oil prices. The interconnectedness of the energy economy within the United States, as well as the widespread reliance on fossil fuels up and down the production and distribution chain, make sustained growth of the ethanol industry uncertain at best.

Conclusion

In only thirty years, the ethanol industry in the United States has grown from a fledgling industry with a lofty goal - to decrease energy dependence and capitalize on domestic resources - to a full-fledged industry that is making serious contributions to economic and energy-based development. This growth is due in no small part to the vast and complex array of subsidies, policies, and regulations from state and federal governments to spur growth and create sustained profits. While it is clear that U.S. ethanol has been successfully developed, questions remain about its

future. What does this success truly mean? Are there alternates to this growth that would produce more sustainable outcomes?

PART 2: Why Reform Is Necessary

Introduction

It is clear that ethanol is not an inherently beneficial from an environmental perspective. The economic growth of the industry has not created energy independence or any meaningful level of climate change mitigation, nor does it seem likely to do so in the near future. However, the technology behind ethanol production does present an immense opportunity for creating an important foundation for the clean energy economy, which will be the deciding factor in the global politics of the next generation. Therefore, altering the industry so that it truly accomplishes its intended goals is crucial to American politics. That is why reform is so important, and the only way to redirect the industry is through meaningful reform of the governmental policies that support and define it. By critically analyzing the various components of the policy structure that supports ethanol and determining which elements must be preserved, altered, or removed, a sound and sustainable industry can be achieved.

To do this, the goals must be clear. In the United States, these goals are fairly simple. Corn-based ethanol has proved to be the primary source of contention in environmental and social terms. Therefore, an appropriate policy in the United States will seek to promote sustained growth of so-called 'advanced biofuels', or second generation ethanol. These cellulosic sources and fuel-conversion technologies hold the key to a sustainable future. This section draws important

distinctions between these two camps of biofuels to explain why reforming governmental policy to give preferential treatment is such a necessity.

The negative environmental impacts of corn ethanol

Critics of ethanol have long pointed to a laundry list of environmental concerns associated with the production, distribution, and consumption of ethanol. For the most part, these concerns are centered on corn cultivation. While most governmental analysis of ethanol's contribution to greenhouse gas emissions focus on the fuel's ultimate use in an engine, environmentalists argue that to fully understand its impact, a life cycle analysis is crucial. Incorporating the various costs and inputs associated with growing and harvesting corn gives a more complete picture of conventional ethanol.

It is commonly understood within the environmental community that traditional agriculture, as it exists in industrialized developed nations, has the potential to cause ecological harm in several ways. Massive plantations of monoculture crops with heavy use of pesticides and fertilizers tend to wreak havoc on biological diversity and habitat integrity (Fargione). A University of Wisconsin study revealed dramatic differences in the integrity of bird populations between annual crops such as corn and more diverse perennial crops such as grasses. The authors used the terms "low input, high diversity" and "high input, low diversity" to describe these two types of crops. Their study found that crops like corn, which require significant chemical and mechanical inputs without any species diversity to support different insect populations, had a profoundly negative effect on bird populations. If expansion of these crops continues at their current rate, the authors

predicted a loss of species richness of up to 65% in some regions of the Midwest. In contrast, the crops more often used for advanced or second generation biofuels, which exhibit high diversity without the need for heavy external inputs, have the potential to improve bird populations in certain areas, and possibly help certain at-risk species recover (Meehan). Another point of environmental concern is the water usage associated with corn production. On average, it takes nearly 155 gallons of water for every gallon of ethanol produced, the majority of which is used during corn harvesting. Only about 30% of this water is returned into the groundwater, while the rest is lost through evaporation or transpiration (Fargione). With climate change presenting serious threats to water availability and longevity, continuing to create energy in ways that demand such dramatic amounts of water is simply unsustainable and counterproductive.

With the advent of biofuels, demand for corn has risen dramatically over the past 30 years. Ethanol alone demands approximately 9 million hectares of cornfields for its production capacity. Considering total annual corn harvesting area is approximately 36 million hectares at its current rate, it is easy to see the impact of ethanol on the U.S. corn market. In order to satisfy the thirst for ethanol while demand for feed corn remains relatively constant, previously unfarmed prairie in the Midwest and retired cropland from previous years has been taken over by the rapidly expanding corn industry. Ethanol has become a primary driver for the unsustainable practices of the corn industry; as farmers attempt to squeeze as many bushels as possible out of every acre to reap the profits of a growing industry, they neglect to let fields lay fallow between harvests, grow crops closer together, and rely

on new hybrid or even genetically modified seeds to withstand the harsh realities of over cropping. As a result, soil erosion and nitrogen pollution are rampant across the Corn Belt, and ecosystems are at severe risk of collapse as they become more vulnerable to pests and drought, rather than building resilience through crop variety and genetic diversity. Industrial agriculture also requires considerable fossil fuel inputs. Combining the petroleum used in most fertilizers, the gasoline needed to fuel the tractors and combines during harvest, and the trucks and trains needed for distribution and delivery, every bushel of corn requires between a quarter and a third of a barrel of oil (Pollan). Considering that ethanol is supposed to wean the United States off of foreign oil imports, and prevent us from emitting more carbon dioxide through the combustion of fossil fuels, it is clear to see the paradox that corn ethanol presents.

When viewed as another product of the corn industry in the United States, it becomes clear that ethanol is not living up to our current environmental standards. Industrial agriculture is responsible for a host of ecological problems, among them excessive fossil fuel use, a problem that ethanol was created specifically to counteract. If land use, energy input, and ecological harm are taken into account, it is clear that deriving ethanol primarily from corn is counterproductive at best and dangerous at worst.

Overview of cellulosic ethanol

Advanced biofuels hold the key to a sustainable future for the U.S. industry. Contrary to corn ethanol, these sources are not associated with the same level of industrial agriculture, and therefore represent a fuel source that is both

energetically and ecologically efficient. Although cellulosic feedstocks have not reached nearly the same level of volume and economic growth that corn ethanol has enjoyed, the technology is sound and carries the potential to grow to the same standard of efficiency and competitiveness in the future. After reviewing the basic process and current strategies being employed with these second generation biofuels, a vision for sustainable ethanol will appear more realistic.

The primary difference between first and second generation biofuels is the location and availability of the energy content within the feedstocks themselves. With first generation sources such as corn, the carbon chains that are necessary for combustion are located in starch molecules that can be directly converted to liquid energy through the process of fermentation. The refineries obtain pure ethanol by essentially adding yeast to the starch, and distilling out the water. In contrast, with second generation sources, the energy content is not as concentrated, and therefore the use of enzymes is necessary to extract the carbon chains and convert them into liquid fuel (Hunt *Biofuels for Transportation*). This primary difference is the source of the price gap between the two fuels. Since advanced biofuels require a more complex and technologically intensive production process, their costs are significantly higher than conventional corn ethanol. As a result, the commercialization of these fuels has not taken off in the United States. However, the nature of the cellulosic feedstocks is what makes them a more sustainable and logical approach to biofuels. Industry and government officials are beginning to recognize their potential to correct our current system, and growth in this sector is increasing rapidly.

The feedstocks for advanced biofuels can be derived from a number of sources, including waste products and cellulosic plants. Cellulosic plants include various types of grasses and other perennial crops. Other sources can be municipal, agricultural, or forestry waste products. Both the plant-based and waste sources require substantially less energy inputs than corn harvesting. Production processes have been tested that create transportation fuels out of wastes such as cooking oil and the elements of plants that are usually discarded during agricultural harvests. These technologies virtually eliminate the need for energy input, and assist in the control of waste streams and pollution. Additionally, the cellulosic feedstocks are uniquely beneficial in a number of ways. The grasses that are often used are perennial, can be planted alongside other crops in diverse agricultural plots, and require "modest water and fertilizer requirements" which help prevent the ecological harms that are associated with more traditional agriculture (Hunt *Biofuels for Transportation*). These crops are also more robust than corn, and can be grown on a more diverse spectrum of land types, and even previously degraded lands. This prevents the need for further expansion in the fertile lands of the United States, allowing the most productive areas to be used instead for food production, as well as creating a more dispersed ethanol industry that would eliminate some of the concerns and costs associated with distribution and transportation. The energy input necessary for these crops is miniscule compared to other sources of fuel, including corn ethanol. For one unit of fossil fuel input, cellulosic ethanol can contain up to 36 units of fossil fuel-equivalent energy. This energy balance

dominates the fuel market, far above corn ethanol's 1:1.5 ratio, or even Brazilian sugarcane ethanol's 1:8 (Hunt *Biofuels for Transportation*).

These characteristics of advanced biofuels have made them very attractive to investors and venture capital firms, as well as government funding for research and development projects. A study conducted by the USDA and the DOE found that within 25 years, if combined with a significant improvement in vehicle fuel economy, advanced biofuels could account for 75% of U.S. transportation fuel (Hunt *Biofuels for Transportation*). It is clear that those in positions of authority and power are beginning to recognize some of the potential benefits and successes of cellulosic ethanol. One particularly interesting and compelling case study is that of the company Verenium. It has received a fair amount of recognition in the industry because of it's partnership with oil giant British Petroleum. The investment by BP was simultaneously the largest single investment in a cellulosic biofuels company in the United States, as well as BP's largest investment into U.S. biofuels overall (Howe). This landmark support demonstrates the potential of Verenium's proprietary technology, as it elicited the interest of a company that has spent considerable resources searching for ways to diversify its energy services and provide more sustainable, environmentally friendly practices.

The technology essentially works by employing a two-part fermentation system that treats the two components of the cellulosic inputs separately, allowing for more complete use of the energy content. Corn ethanol is simpler to ferment because it contains one primary source of energy, the six carbon sugars in its starch molecules. Cellulosic sources often contain nearly equal levels of six carbon and five

carbon sugars, the latter of which cannot be fermented using the same process. Verenium uses two separate organisms and production lines to ferment both types of sugars, allowing them to dramatically enhance the energy output of their feedstocks (Howe). This case study demonstrates some of the technological advances that are happening currently in the ethanol industry that ensure a more sustainable and realistic future for ethanol in the United States. These companies are focusing on processes that increase energy efficiency and minimize environmental damage, contrary to the corn ethanol machine that is often more focused on increasing profit margins and securing government tax relief.

There is no doubt that significant barriers exist for the large-scale growth of cellulosic ethanol. The enzymes themselves are expensive to acquire and maintain, and the production process requires large amounts of them. Additionally, the complexity of the fermentation process requires more steps than conventional ethanol, which means more time, equipment, and careful monitoring. Current research and development projects are investigating ways to overcome these difficulties, but increased investment into this research is essential for advanced biofuels to become truly commercially viable. Many experts are confident that if these hurdles are overcome, the industry could reach great heights. The theoretical capacity for the United States to grow cellulosic sources of ethanol is almost equal to our demand for fuel. We have the potential to grow 1.3 billion tons of biomass per year, in addition to our agricultural and forestry needs. This is the equivalent of about 130 billion gallons of ethanol per year, 10 billion short of our annual consumption of gasoline (Somerville). It is certainly reasonable to assume that with

increases in public transit and fuel economy, and improvements in the infrastructure of ethanol consumption, the country has the potential to be entirely independent of fossil fuel use in terms of transportation. Provided the economic barriers to cellulosic ethanol are overcome, a sustainable industry is possible in the future.

What's wrong with current system?

Reform is necessary is because the current system has not produced the desired outcomes for the ethanol industry. As the previous two sections have demonstrated, there is a right and a wrong way to produce ethanol, and the wrong way has benefited too heavily from long-standing structures. To move forward and create sensible policies for the future of the ethanol industry, we must first evaluate the status quo, and understand why it has been ineffective to date. By analyzing the failures of dominant policy, the path towards sustainability will be clearer.

Unlike many policy areas, including those dealing with environmental issues, the policy of ethanol in the United States has never been given full and singular attention. There is no Ethanol Policy Act, but rather a series of regulations, subsidies, and targets created as part of a separate legislative initiative, and never organized into a unified policy goal. This has resulted in a variety of unintended consequences, and has prevented the industry from being fashioned in a sustainable, science-based manner. Many critics point to a common problem of democratic politics, especially here in the United States, called the Iron Triangle. This refers to the process by which legislative agendas get hijacked by the three most powerful influences of Congress, Executive Branch agencies, and Interest

Groups, rather than being driven by scientific realities or public interest (Chatrchyan). In the case of ethanol, the combined forces of the corn lobby and the refiner's associations present a formidable force in Washington, making reform to the system challenging.

Another difficulty presented by the current political climate is the struggle over true motivation for expanding the industry. Chatrchyan points to the so-called "Bootleggers versus Baptists" concept, which describes how groups with different motivations (economic incentive for bootleggers, moral incentive for Baptists) can come together on a singular issue (banning the sale of alcohol). With ethanol, these two camps are not so clearly defined, and it becomes difficult to separate the true motivators. In response to growing concern over climate change, and international efforts to curb greenhouse gas emissions, many officials from the corn industry have suddenly turned into environmental advocates, fighting for government support of ethanol to help solve our collective problems. In a situation such as this, it becomes difficult to separate the motivators, and therefore the goals, of a given policy. Initiatives get shaped by those who claim to be fighting for sustainability, but are in reality searching for ways to maintain economic growth and profit margins (Chatrchyan). Ethanol policy in the United States has essentially manifested itself as a continuation of the corn industry's lobbying efforts. It is no surprise, therefore, that the policy structure has favored the conventional forms of ethanol production over the technologies that can realistically achieve the environmental goals sustainably and practically.

One particular consequence that has been observed as a result of ethanol subsidies is the impact on the Highway Trust Fund. Established in 1956, the fund was essentially a way of taxing citizens who used private means of transportation to help pay for a national highway system. The majority of the fund is financed through federal excise taxes on motor fuel (Rask). Since the primary subsidies to ethanol are based on exemptions from those excise taxes, the two policies have become inextricably linked. Hence, the more ethanol subsidies that are awarded as more producers come online, the less money is aggregated in the Highway Trust Fund. Not only does this impede the federal government's ability to fund the infrastructural improvements necessary to keep transportation lines functioning, it also creates disparities between states. Since ethanol production is concentrated in a handful of U.S. states, free riding is a common challenge. States like Iowa and Minnesota, whose residents do not have to pay as much of the excise taxes as other states due to ethanol subsidies, still receive an equal share of the apportioned payments from the fund. However, the obvious solution to this discrepancy is also problematic. If the disbursements from the Highway Trust Fund were altered to reflect how much money was received from each state, ethanol states would receive less money for highway construction and improvement, even though their fuel and vehicle use had not declined (Rask).

The counterintuitive nature of this policy connection makes it difficult to comprehend. If ethanol production continues to grow in a sustainable fashion, fostering continued growth in the transportation sector of the economy, we should be seeing increases in programs such as the Highway Trust Fund, not a decline. As

environmental writer Bill McKibben notes in his most recent book *Eaarth: Making Life on a Tough New Planet*, one of the biggest threats that climate change poses to our economic stability is to our infrastructure. As storms increase in frequency and intensity, and the climate behaves in ways outside of what we have built and prepared for, the costs associated with reconstruction and resilience will be extremely high (McKibben). If we want ethanol to help better prepare us for the next 100 years of climate change, and reduce our impact and role, we should not be fashioning policy that deteriorates our ability to respond to climate related crises.

Another negative consequence of the U.S. ethanol subsidies machine is its impact on corn prices. Between 2004 and 2008, the rapid and severe climb of crude oil prices drove ethanol demand skyward, and have been a significant factor in its sustained growth to date. During this period, corn prices shot from $2 per bushel to $6 per bushel. While some of this increase can be attributed to higher input costs associated with the higher oil prices, ethanol demand also had a serious impact. One study assigned 25% of this $4 increase to the increase in ethanol demand, or a total of a $1 per bushel rise (Taheripour). Considering the baseline price of corn, it is clear that ethanol has a meaningful impact on demand, and therefore price. This relationship has serious implications for food costs at home and abroad. Side effects like these have demonstrated that our ethanol policy is affecting our economy and our environment in ways that we neither intended nor desired.

Conclusion

When special interests and economic incentives take precedence over scientific imperatives and long-term sustainability in the formation of public policy,

outcomes are rarely optimal. The past 30 years of patchwork ethanol policies have resulted in a system that favors the conventional, easy solution rather than the more challenging options that are more sustainable and supported by science, academia, and the general public. Our current industry is creating a host of ecological problems and doing little to solve the energy or economic issues that it set out to address. It is clear from the difference between conventional and advanced biofuels that the nature of government policy is responsible for the system that has so underwhelmed us. Government support structure must be reevaluated and reformed. The next and final section will analyze the good, the bad, and the ugly of the current system to determine which elements can and must be preserved to foster the correct kind of growth, and which must be eliminated to achieve a sustainable industry.

PART 3: The road to a sustainable biofuels industry

Introduction

No system is perfect, and the political process in the United States has its share of problems. The last section demonstrated the shortcomings in the political realities that have shaped ethanol policy in the United States. However, our current structure should not be abandoned completely, and a new system crafted from scratch. There are elements to ethanol policy, including monetary support of the industry, that are helpful in promoting the appropriate levels of growth in the right places. Moving forward, the essential question becomes: what stays, and what goes? There are a variety of systemic and monetary supports that will be crucial in the short-term to foster a sustainable biofuels market. Additionally, there are policies

that are currently nonexistent or lacking in adequate attention that deserve inclusion in the overall system. This section examines the politics of ethanol in the United States, and how this issue has become so protracted and controversial. It concludes with a review of what systemic supports will be necessary to support a sustainable biofuels industry, and outlines a path to reform.

The politics of U.S. ethanol subsidies

Part of what makes the battle over ethanol so challenging is the complex politics behind it. Unlike many controversial issues in Washington, ethanol is not a struggle along party lines. Preconceived notions of America's future are left at the door when dealing with ethanol, and it is often surprising to discover the largely bipartisan support that subsidization enjoys. Instead of the traditional ideologies taking sides over the issue, ethanol policy is geographic. Politicians from Midwestern states, whose constituencies rely on the economic success of corn farmers, advocate fiercely for strong government support of ethanol because it provides their districts with more money and more demand for the corn they grow. Senator Tom Daschle (D-SD), the former Senate Majority Leader, was quoted as saying "Farmers and ranchers are not going to survive unless we expand our base of marketable products". The argument for supporting American Corn Belt farmers by adding ethanol to their list of markets has reached the highest levels of power in Washington. In addition, the bloc of farm state politicians has become so powerful that policies like ethanol tend to gain even more support from other lawmakers trying to gain favor or trade votes (Economist). In such a fiercely partisan and heated political climate as we have seen in the past few decades, politicians are

eager to latch onto a policy that can actually be agreed upon, and wave it around as a testament to the ability of Washington to reach a consensus. In this spirit, provisions on mandating ethanol have often taken precedent over other energy related mandates, such as renewable electricity portfolio standards and higher fuel economy, which are more divisive issues. Ethanol in particular is also a perfect example of a policy that is easy to sell to voters and the American public. On the surface, it makes perfect sense. We have surpluses of corn, a commodity that is easily and readily produced, so why not utilize that resource to enhance our energy independence while combating climate change? In the talking points and stump speeches, the underlying issues of land use, long-term sustainability, and environmental habitat preservation get lost.

The corn lobby uses a variety of tactics to secure continued subsidies and government support for ethanol. They argue that our capacity to grown corn far exceeds our supply. Without a large ethanol market, this difference would have to be met by a combination of paying farmers to decrease their production, exporting surplus corn overseas, and using it for aid shipments to developing nations. Instead of these solutions, which are costly and create little-to-no return on investment, lobbyists advocate for utilizing the energy market to soak up the excess agricultural product with its growing demand (Hirschfeld Davis). Clearly, these efforts are not without staunch opposition. As previously mentioned, California Senator Dianne Feinstein has been vocal about her distrust of the ethanol subsidy system and its implications for federal and statewide energy initiatives. Along with other politicians from heavily populated states along the coasts of the U.S., she has argued

that subsidizing ethanol essentially amounts to a massive transfer of wealth from all of the states where people live, drive, and use the most energy, to a handful of states and their ethanol manufacturers (Hirschfeld Davis). This debate demonstrates that the politics of ethanol development in the United States has been diverted from a reasonable path. Instead of focusing on addressing the environmental concerns of corn ethanol, or honestly evaluating how to use biofuels to solve our energy and environment challenge, the debate has been centered on how much money ethanol producers deserve. The political influence of the corn lobby has made it virtually impossible to question the underlying logic behind ethanol; instead we are left to argue over the margins of subsidies and government support. In the future, more incorporation of scientific data and long-term solution building will be crucial to craft the correct type of policy.

Monetary and systemic supports necessary to create a sustainable ethanol industry

The path to creating a properly sustainable biofuels industry in the United States will not be easy. Breaking down the political barriers to reform a project of considerable difficulty, and the policies themselves will not be easy to implement. However, given the potential that an environmentally conscious ethanol policy could have towards generating the energy economy of the future, this path deserves full attention and dedication. It will require changes in infrastructure, political divides, and policies in a range of issue areas. I will explore these changes and conclude by examining what it will take to move towards their implementation.

The biggest barriers to ethanol development in the United States are not associated with the costs of production or with the supply more generally, but with

the demand. The infrastructure in place prevents consumers from having equal access to ethanol and gasoline, making a comparison of economic viability between the two difficult. As previously mentioned, the pipeline network of gasoline gives it a significant advantage over the transportation costs of ethanol. However, there is a far more important infrastructural barrier that limits the growth of any ethanol industry in the United States: the blending wall. The blending wall refers to the limit at which ethanol can be incorporated into gasoline without making any changes to our current transportation system. There are currently two main types of ethanol blends on the market: E10 and E85, which refer to the percentages of ethanol contained in the fuel. E10 is used identically to regular gasoline; its consumption in an engine does not have any negative effects. E85, on the other hand, is a different fuel that requires a different engine, as well as specific pumps and pumping stations to satisfy the needs of drivers who use it. Car manufacturers have typically been opposed to introducing blends higher than E10 without creating special flex-fuel vehicles to run on them. According to car insurance standards, running a traditional engine on an ethanol blend higher than E10 would void the warranty on your vehicle, since auto manufacturers do not trust the compatibility of these two technologies (Taheripour). ”Wall” is therefore an apt term, because it amounts to a fairly rigid limitation on the amount of ethanol that can be absorbed in the market. Since E85 fuel requires such a heavy investment in infrastructure, the demand for biofuels in the United States is currently a restrictive factor on growth of the industry.

To break the blending wall, as well as the other practical limitations on ethanol consumption, significant investment will be required. New pumps, new engines, and new pipelines will all require large amounts of capital. However, when viewed in the context of overall government support for ethanol, it is more feasible to imagine a turnover of this magnitude. If the current system of subsidies is revised to reflect actual necessities in the costs of production, the money can instead be used to build those long-term solutions to the ethanol problem. The taxpayers' money would be much more wisely spent on building the infrastructure necessary to create a sustainable industry than on supporting the technologies and processes that do more harm than good. Various scholars have proposed changes to the subsidy framework that would reduce overall payments in the short term, and help start the industry on a path towards independence. I will examine the three main approaches individually, and analyze which policies are the most helpful and feasible in generating the wealth necessary for a sustainable industry.

The first approach deals with greenhouse gas emissions, and attempts to link ethanol and agriculture more generally with the climate change regime. The current framework for addressing climate change and reducing emissions focuses mainly on electricity production and heavy industry, which are typically the largest emitters of carbon dioxide. It makes sense to single out coal-fired power plants and steel factories, because of their potential to make a large impact on overall emissions. However, when life cycle analysis is used, agricultural products like commodity corn and biofuels can also have a serious influence on greenhouse gas emissions, and correcting this pattern can have a net positive effect. Some have argued that

extending GHG considerations to agriculture would allow us to reach a lot of 'low hanging fruit'; inexpensive and attainable initiatives that will produce concrete results (Hunt "Biofuels, Neither Saviour or Scam"). Using concepts like carbon credits and a cap-and-trade market in the agricultural sector would incentivize sustainable practices in the ethanol industry, and avoid some of the counterproductive consequences of production. Under this framework, cellulosic ethanol would also come out on top of first generation sources, because of its clear advantage in input-based emissions. In comparison to corn ethanol's 12.5% reduction in carbon emissions relative to gasoline, cellulosic sources can show up to a 275% reduction, because many feedstocks sequester more carbon in their growth than they emit during production and end-use (Tyner). Rather than using the current fixed system of the VEETC, ethanol subsidies could be improved by incentivizing lower emissions on a scaled basis, which is the true purpose of ethanol in the long run.

Another strategy for improving the ethanol subsidy structure is by connecting them to crude oil prices. This approach essentially views energy security and the domestic creation of fuel to be the most important and influential drivers of ethanol production. Since ethanol is the main alternative to gasoline in the current market to portable transportation fuels, the price of oil is the primary driver of demand for ethanol. As gasoline becomes more expensive, the demand for ethanol will increase, and the price will go down, allowing for further development of the industry. Since crude oil prices are only predicted to increase over the coming years as reserves are depleted and our relations with Arab nations continue to be tense at

best, some argue that the subsidization of ethanol should only be in place while the price of oil is still cheap enough to prevent growth of the industry. Linking the subsidy to the price of oil would normalize the relationship between the two fuel choices, and allow for the market to dictate growth. This strategy would essentially scale down the subsidy for ethanol as gasoline becomes more expensive, and eventually eliminating it altogether once the price reaches a certain level that makes demand for ethanol the obvious preference (Tyner).

In order for this approach to be successful, it would need to take into account two important factors: the impact of oil price on corn prices, and the unreliability of the oil prices themselves. As previously mentioned, oil prices have a serious impact on corn prices due to the need for fertilizers and harvest machinery that rely on fossil fuels. Therefore, the connection between the ethanol subsidy and the crude oil price would have to be adjusted accordingly to reflect this relationship. At a point of high crude oil prices, the subsidy would still have to be enough to compensate for the price of corn. However, the hope with this policy is that rather than continuing to depend on fossil fuels to create ethanol, the increases in crude oil prices, combined with the associated reductions in subsidies, would incentivize more sustainable and fossil-independent forms of production and feedstock growth. The unreliability of oil prices is also an important element to this approach. Although the simple economics of a finite resource combined with strong scientific consensus on peak oil demonstrate a long-term rise in oil prices, it is not an easy prediction to assume that prices will be rising steadily in the short or medium term. Additionally, fossil fuels are subsidized worldwide, so a policy based on their prices could never

reflect the full externalities of their production. In order to achieve an accurate subsidy system that is tied to crude oil price, market distortions for fossil fuels would eventually need to be eliminated as well.

A final option for altering the current system of government support is to eliminate or dramatically reduce import tariffs. Although the tariffs currently in place have a strong influence on the growth and economic viability of domestic ethanol, removing them could have positive impact on the sustainability of ethanol overall. Since Brazilian sugarcane ethanol, the only other major source for international consumption, has an 80% reduction in carbon emissions compared to corn ethanol's 12.5%, importing more foreign ethanol would have a net positive impact on the United States' carbon emissions (Elobeid). In order to preserve the proper types of development of U.S. ethanol alongside this policy, the incorporation of greenhouse gas emissions into our domestic policy would be crucial. Since cellulosic ethanol has a better net influence on carbon emissions than sugarcane, these two policies together would ensure that only the best forms of ethanol, in terms of environmental impacts and true sustainability, would be produced.

These three strategies for reducing the U.S. government's overall influence in the ethanol market are important tools for creating a sustainable industry. Incorporating carbon credits into the agricultural market and the ethanol industry, tying overall subsidies to the crude oil price, and liberalizing trade to bring in more sustainable ethanol sources from overseas could all promote the proper forms of growth for the ethanol industry while saving the federal government money, which

could be used on the types of infrastructure necessary to open up demand for a real ethanol industry in the United States.

Conclusion

Historically, the U.S. government's policy on ethanol has been to provide monetary assistance that allows the most efficient form of ethanol to build the capital it needs to grow more production capacity. This policy, as I have demonstrated, has been at best short sighted and at worst ineffective. To solve the environmental and economic issues it is meant to address, cellulosic ethanol must become the norm in the United States. Its superiority in terms of carbon emissions and environmental damage makes it the sustainable choice for the future of transportation fuel in this country. To allow for this growth, the standards of subsidization have to change to reflect real necessities in our system, and the government needs to focus its financial efforts on the projects that need the most investment now to ensure sustained growth and prosperity in the future. Building the infrastructure that can break down the blending wall will require considerable capital at the federal, state, and local level. But this investment can come from the public sector as long as the subsidy system is reevaluated. True reform can only come if the right voices are heard in the formation of policy, including the hard science that supports these claims. Instead of creating policy based on the economic interests of corn lobbyists and politicians from a few key states, the long-term energy needs of the country must take precedence. I will conclude by discussing the political climate we need in Washington to support the necessary reforms for the ethanol subsidy system.

Conclusion: How We Get There

Politics is the means by which we organize the world around us and solve our collective problems. For the play of politics to function properly in an increasingly complex world, and for the problems engendered by this complexity to be solved successfully, the solutions we choose must be based upon facts, long-term thinking, and the scientific method. As importantly, any successful solution must make true economic sense. As the most recent economic recession has demonstrated, it is nearly impossible to accomplish policy goals in Washington if they don't foster economic growth, create jobs, or at least do nothing to prevent these from happening. The science of climate change and the technology for converting the sun's energy into vehicle fuel both support the same conclusion - the most sustainable and economically viable method for replacing our fossil fuel system is not corn-based ethanol; it is to produce second generation advanced ethanol from cellulosic feedstocks. The international scientific and academic communities concur. As politicians like Diane Feinstein demonstrate, the consensus for reform is even spreading to members of Congress. In fact, the only actors who still maintain that the current system is beneficial and smart are those who are strongly influenced by the corn industry lobby. Representatives from Midwestern states and members of key committees have been targeted by 'King Corn' to drive demand for their product, no matter what the economic or environmental cost.

Ethanol policy in the United States is an excellent example of regulatory capture. Instead of creating a fuel system that challenges energy dependence and helps with climate change mitigation, our public officials have been corrupted by the

thinly veiled motivations of the conventional ethanol machine. Our system has resulted in little improvement towards energy security or emissions reductions, and has left us with ecological damage, concerns over food prices, and no clear path for the future. To break this cycle, it is imperative that the data behind ethanol is truly incorporated in discussions of policy and that those policy discussions not be skewed by ignoring economic externalities. The best way of achieving this input is by treating ethanol, and America's energy future more broadly, as a unique and important national issue that transcends local or state-level economic pressures. Instead of the scattered policies at the state and federal level over subsidization of ethanol, we need a central piece of legislation that has clear goals of reducing greenhouse gas emissions and limiting foreign oil imports. If a policy has these directives, the choices for appropriate governmental support will become abundantly clear.

Fossil fuels will not last forever. Nonetheless, our economy and our society are dependent upon the vast networks of fast and reliable transportation. If we have any desire to prevent catastrophic disruptions to that system, a forward thinking adjustment to our fuel policy is imperative. Corn ethanol amounts to an incomplete and at times counterproductive solution to the problem of fossil fuels, and yet our national policy favors it over more sustainable options. We would do well to reshape this policy to achieve the goals we set out to achieve.

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