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Growing Towards a Sustainable Biofuel Future

A Comprehensive Policy Strategy for Navigating Tradeoffs and Stakeholder Interests in U.S. Agriculture

Final Report – ESD.10 Introduction to Technology and Policy

Pearl Donohoo
Don MacKenzie
Jeff McAulay
Julio Pertuzé
Addison Stark

Massachusetts Institute of Technology
Technology and Policy Program

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1 Executive Summary

Rapid growth of biofuels production in the United States is reshaping the agricultural industry, delivering both benefits and conflict among stakeholders. Routes forward on biofuels production should be viewed in the context of economic, land use, environmental, and energy security trade-offs and their potential impacts in the future. This report discusses the current, emerging, and prospective conflicts arising from increased biofuels production, recommends policies to resolve these conflicts, and identifies likely areas of support and opposition from stakeholder groups. The report focuses heavily on ethanol, because ethanol accounts for 95 percent of U.S. biofuels production (Worldwatch 2006); however, many of the trade-offs and recommendations identified in the report can and should be applied to biofuels more generally.

This report does not attempt to assess whether or not biofuels are the best option for transportation fuel use. Rather, it accepts that current mandates, policies, and market conditions will result in increased biofuel production and proposes policies to support growth in more economically and environmentally sustainable manners.

1.1 Drivers of Ethanol Growth

The growth of the biofuels industry is driven by the goals of addressing environmental issues, rural economic development, resource potentials, and energy security (Charles 2007). From these ideological drivers, policy initiatives have been enacted that act on feedstock producers, biofuel producers, and fuel users. Farmers are guided by a range of policies aimed at protecting sensitive lands and maintaining soil quality, while ensuring adequate incomes for farmers. Fuel sellers who blend ethanol into their fuel mix receive a tax credit of $0.51 for each gallon of ethanol they use. Small-scale ethanol producers receive an additional $0.10 income tax credit for each gallon produced. A recently established renewable fuels standard (RFS) requires fuel sellers to include a certain amount of renewable fuels (which largely means biofuels) in their fuel mixes. The RFS requires the use of 4 billion gallons of renewable fuels in 2006 and 7.5 billion gallons in 2012 (Tyner 2007).

1.2 Stakeholders

Analyzing the lifecycle of a biofuel from the production of feedstocks through end use reveals a number of unique stakeholder groups, illustrated in Figure 1-1.

1. Agricultural Suppliers: provide feedstock producers with seed, chemicals, and equipment.
2. Feedstock Producers: grow the raw material used in biofuel production, most often farmers.
3. Competing Feedstock Users: compete with biofuel producers for limited quantities of crops, most prominently food producers.
4. Ethanol Producers: convert the feedstocks into marketable ethanol.
5. The Petroleum Industry: produce the standard petroleum-based fuels that the biofuel is intended to supplant.

6. Non-Traditional Substitutes: produce competing non-traditional fuels, most prominently chemical and competing biofuel companies.
7. Fuel Users: operate the vehicles that consume the biofuel.
8. Environmental and Public Health Interests: evaluate biofuel effects on environmental quality and effects on public health, includes advocacy groups and governmental agencies.
9. Automakers: produce vehicles which use biofuels.
10. Government: seek balance between constituent interest, budget constraints and current policies and international agreements

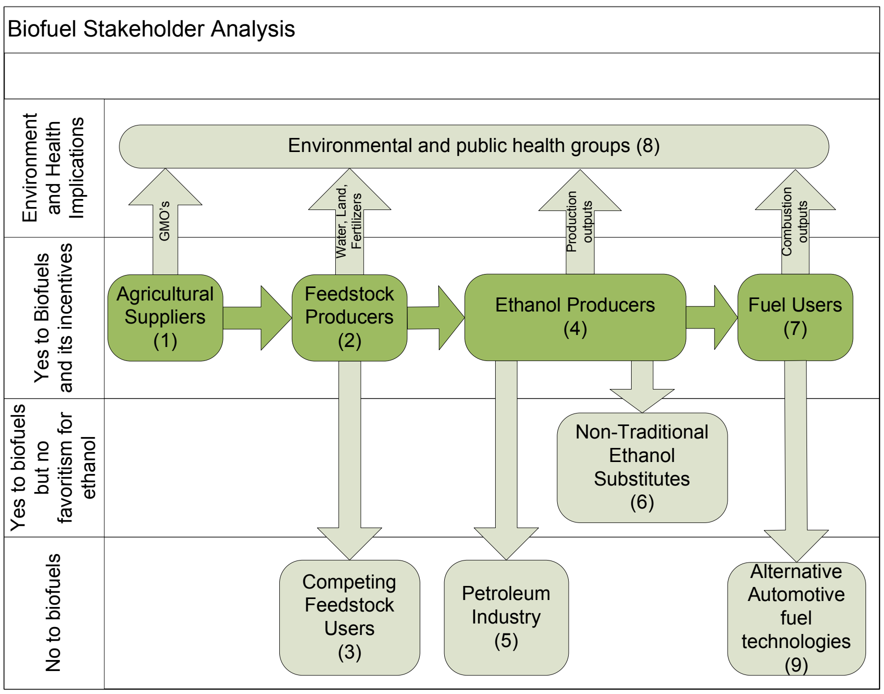

Figure 1-1: Biofuel industry stakeholders

1.3 Trade-offs In Biofuel Growth

Production of biofuels faces a variety of significant trade-offs. These trade-offs include dramatic impacts on the environment, public health, food supply, and energy security. The trade-offs discussed below focus on the current domestic corn-based ethanol production. These and other trade-offs are discussed in depth in the full report.

Global Warming Pollution

Current ground transportation fuels are significant sources of greenhouse gas emissions. Corn ethanol in the U.S. delivers modest reductions in global warming pollution compared with the gasoline it replaces (Groode 2007). However, increasing corn production will lead to increased nitrogen fertilizer use and a corresponding increase in emissions of the global warming pollutant through nitrous oxide. Advanced biofuel technologies have the potential to reduce global warming pollution significantly (Groode 2007), helping to mitigate this trade-off.

Energy Security
Energy security is defined as reducing the economic risk to the United States of interruptions or severe price fluctuations of energy supply. Energy security can be improved by (1) reducing the economy's dependence on energy through greater efficiency, (2) producing more fuels domestically, or (3) increasing the diversity of fuel sources used. Today's ethanol does not significantly add to energy security. Assuming today's conversion rate, utilizing 100 percent of corn production would only yield 15 percent of fuel consumption; therefore, a trade-off exists between protecting domestic biofuel producers and maximizing the total usage of biofuels (including imports)[1].

Food Prices
Ethanol production competes directly with livestock feed and other food uses of corn, and indirectly with food production through competition for land. This competition has already cost food consumers approximately $15 billion (Alexander and Hurt 2007; Tokgoz et al. 2007). Expanding current ethanol production will further increase this competition, but this trade-off can be reduced by transitioning biofuel production to non-food feedstocks.

Water
Agriculture already contributes to a degradation of water quality and the depletion of aquifer levels (NAS 2007), and the continuation of intensive biofuel production will exacerbate the problems. Nitrogen runoff from agricultural land causes hypoxic dead zones in Chesapeake Bay and the Gulf of Mexico, in which marine life is unable to survive because of a lack of dissolved oxygen (NAS 2007).

Soil Quality
Corn and soybean rotations have been developed to help maintain soil quality and reduce the need for fertilizer application; however, demand for corn is disrupting these standard crop rotations. Furthermore, cellulosic biofuel production will create an incentive to remove agricultural residues that are currently left on the field to help maintain soil nutrient levels and prevent erosion.

1.4 Recommended Policy Portfolio

The trade-offs listed above constitute the consequences of continued biofuels growth. In order to realize the energy security, climate, and economic potential of greater biofuels use, this report recommends a combination of policies that will mitigate the risk of new investments in biofuels production, drive a transition to more sustainable biofuels production, and create an industry that can compete in a global market.

1.4.1 Phase 1a

The goal of this phase is to reduce risk for biofuel producers and develop a market for advanced biofuels. Currently, the petroleum industry dominates the transportation fuels market; there are established distribution networks and a largely single-fuel vehicle fleet. Because of this environment, new entrants to the fuels industry face two major challenges:

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[1] Ethanol displaced less than three percent of U.S. gasoline demand (EIA 2007b) and consumed nearly 20 percent of corn production in 2006 (USDA-NASS 2007).

1. **Competing on the price of oil**: New fuels will initially hold small market share and must compete as price takers. Because the price of oil is volatile and the viability of new entrants fluctuates with oil price, there is a significant risk that fuel prices will drop and render new entrants unprofitable.
2. **Fuel Demand**: In small volumes, ethanol and other biofuels can be blended with gasoline without appreciable changes in the fuel quality and distribution needs. With increased blend percentages, current vehicles and fuel distribution networks cannot be used.

In order to mitigate these risks, this report proposes four policies. The first policy, an oil price backstop, would help to prevent depressed oil prices and create a more stable environment for competition. The second two policies, flex-fuel vehicle production and infrastructure support, address fuel demand and allow the industry to grow.

1.4.2 Phase 1b

The goal of this phase is to develop the biomass collection, biomass processing and agricultural techniques required to produce sustainable next generation biofuels. Sustainable biofuels address the food versus fuel dilemma as well as environmental implications.

Current production methods will not be able to hold significant market share. Additionally, as discussed in the above trade-offs, today's corn ethanol production does not adequately increases food prices or environmental consequences. Therefore, to achieve a full scale sustainable biofuel industry in the United States, cellulosic biomass feedstocks must be developed .

This report proposes three distinct areas for research: conversion technology, biomass collection, and agricultural methods.

1.4.3 Phase: 2 Market Transition

The goal of this phase is to ready the domestic biofuel market for transition into a liberalized global biofuel market in phase 3. In phase 2, domestic producers will be given a comparative advantage to international ethanol producers by implementation of sustainable biofuel production standards that, in phase 3, all imported biofuels will be forced to adhere to. In order to achieve this market transition, this report proposes three policies. The first of these is to allow harvesting of perennial grasses from Conservation Reserve Program (CRP) land to create a cellulosic feedstock supply with minimal risks to farmers. The second policy is to develop national and international biofuels standards that biofuels must adhere to. The final policy is to change the current tax incentives to CO_2-reduction based incentives.

1.5 Phase 3: Realizing Ultimate Goals for Biofuels Market

The goal of Phase 3 is to create a robust and sustainable international market for biofuels by implementing biofuel standards and liberalizing biomass agriculture to establish sustainable markets. This would bring the following benefits:

1. **Enhanced energy security.** Energy security will be improved by diversifying the types of fuels used and the sources that supply them.

2. **Greater market predictability.** A global market for biofuels would lead to greater stability and predictability in prices and demand. More predictable prices would encourage more consumers to use biofuels, which would increase the size of the biofuel market. A larger and more predictable biofuel market would benefit farmers, who would be able to make long-term planting decisions knowing that there would be a market for their crops. In contrast, a closed market would limit the adoption of biofuels, and price instability due to fluctuations in domestic supply would threaten to alienate consumers.
3. **Global Environmental Sustainability.** By implementing sustainability criteria for all biofuels sold in its market, whether domestically or internationally produced, the United States can ensure the protection of its own environment while encouraging best practices throughout the world. Furthermore, such a requirement will protect American farmers from being undercut by unsustainable biofuels produced abroad.

1.6 Conclusion

The proposed policy package will likely encounter initial opposition from both agriculture and the petroleum industries. The agriculture industry will respond most strongly to the biofuel standards; however, agricultural opposition should be tempered by biofuel growth policies and the increased research and development funds. Diversified fuel companies – those that sell multiple fuels including biofuels – will fight initial policies but may embrace the biofuel sector as it becomes more profitable. Dedicated petroleum companies, for example those who work in upstream production, are unlikely to support any biofuel policies. The way to counteract this pressure is by building a strong constituency for biofuels. Therefore, the success of this three-phase strategy depends upon the correct implementation of each of the sequential stage.

2 Introduction

The production of biofuels in the United States is expanding rapidly, reshaping the agricultural industry and creating both benefits and challenges. Potential routes forward on biofuels production should be viewed in the context of trade-offs between economic, energy security, environmental, and land-use goals. This report examines the U.S. biofuel industry and its current direction, and develops a set of policies intended to grow the industry in a way that maximizes the benefits to all stakeholders.

Biofuels production is growing worldwide, but growth has been particularly strong in the United States (Figure 2-2). The two principal biofuels on the global market are ethanol and biodiesel, but ethanol accounts for more than 95 percent of domestic biofuel production (DOE 2007, NBB 2006) and 90 percent of worldwide production (by volume, Worldwatch 2006). Further, ethanol production in the U.S. tripled between 2000 and 2006 (DOE 2007).

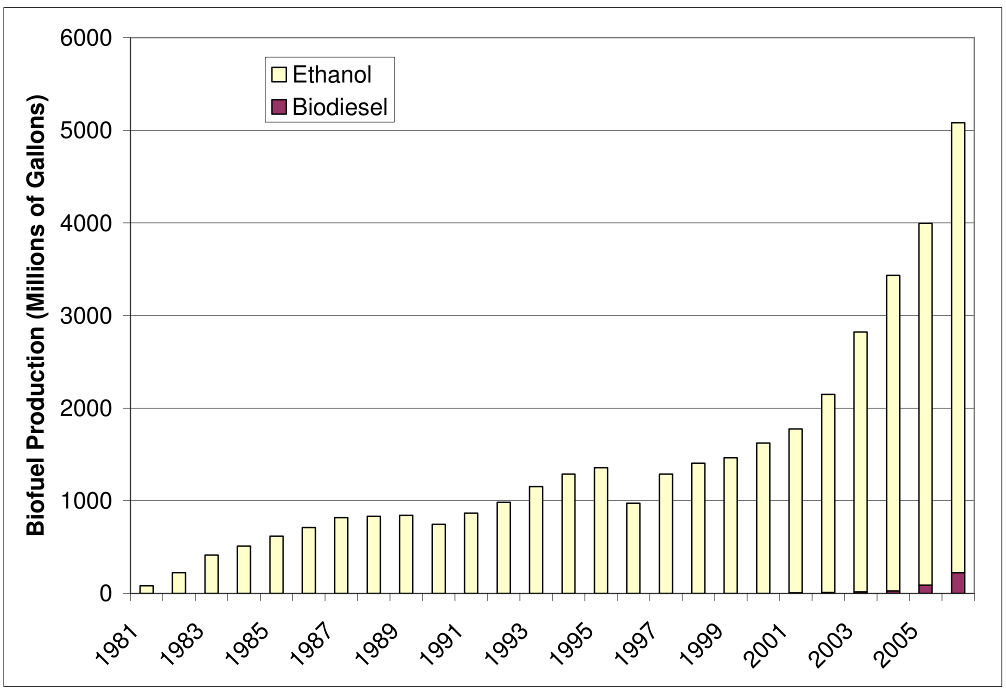

Figure 2-2: United States Biofuel Production, 1980–Present. Source: DOE 2007, NBB 2006.

Due to ethanol's current market dominance and strong growth trends, this report necessarily devotes considerable attention to ethanol. This does not to imply a judgment of ethanol's superiority over other biofuels, but rather reflects its current leadership in the market. Similarly, the report does not presume that biofuels in general are the best option for future transportation fuel supply, but rather accepts that current policies and market conditions will result in increased biofuel production and that biofuels can contribute to a balanced energy portfolio. Critically, many of the conclusions and recommended policies should be applied across the entire biofuels industry.

The recent surge in biofuels production has been driven by a range of policy initiatives, which have in turn been motivated by goals of energy security, environmental sustainability, and rural economic development (Charles 2007). Additionally, biofuel production has implications for food prices and international trade issues, so increased production must be evaluated as a set of trade-offs between many competing interests. This report identifies the stakeholders connected with the biofuels debate and recommends a suite of policies intended to balance the interests of these stakeholders and ensure that biofuels deliver on the goals outlined above while minimizing disruptions on food supplies and satisfying international trade obligations. Section 3 presents a snapshot of the biofuels industry, the policies guiding it, and the stakeholders connected to it. Section 4 discusses the trade-offs between the competing goals of different stakeholder groups, and section 5 develops a suite of policies intended to drive biofuel growth in a way that balances the interests of all stakeholders. Finally, section 6 presents a set of conclusions drawn from the analysis presented in the preceding sections.

3 Background on Current Biofuel Production and Stakeholders

The biofuels industry involves an increasingly wide range of production methods and feedstocks, is influenced by a complex array of government policies, and draws in a diverse set of stakeholders. This section provides some background on the feedstocks and processing methods used to produce biofuels currently, and briefly discusses some alternative production paths that are under development. It also identifies the stakeholders in the biofuels debate and the nature of their stakes. Finally, it outlines the current policy structure governing the biofuels industry.

3.1 Ethanol Production Methods

Ethanol production requires anywhere from two to four major process steps, depending on feedstock used (Figure 3-3), and is generally produced biologically. The final two steps, fermentation and purification, are common to all forms of ethanol production. Fermentation is the conversion of sugar to ethanol by yeast, resulting in a dilute solution of ethanol in water, which is then distilled and purified using molecular sieves. Crops that contain large amounts of sugar can be fermented directly. In Figure 3-3, these crops are labeled Type A. Examples include fruit crops, sugar beets and sugar cane. Starchy (Type B) and cellulosic (Type C) feedstocks require an additional hydrolysis step that breaks down the polysaccharides (the long chains of sugar molecules that comprise starch and cellulose) into fermentable sugars. Type B feedstocks include cassava, corn, Jerusalem artichoke, and sorghum. Type C feedstocks must be pretreated before hydrolysis, to physically expose the cellulose to the cellulase enzymes which hydrolyze it. Type C crops include agricultural residues, aspen, bagasse, corn stover, and switchgrass. Ethanol production from both Type A and Type B feedstocks is mature. Additional information on feedstocks and supplies can be found in Appendix 2:.

Although not yet mature, cellulosic (Type C feedstock) ethanol production has attracted considerable attention recently, because it would be produced from the cellulose fibers in plant cell walls, rather than the edible starch found in grains. No commercial cellulosic biofuel plants are operating and only six domestic demonstration projects are underway (DOE 2007). Nevertheless, the technology is promising and the Energy Information Administration expects that several cellulosic conversion facilities will begin production between 2010 and 2015 (EIA, 2007).

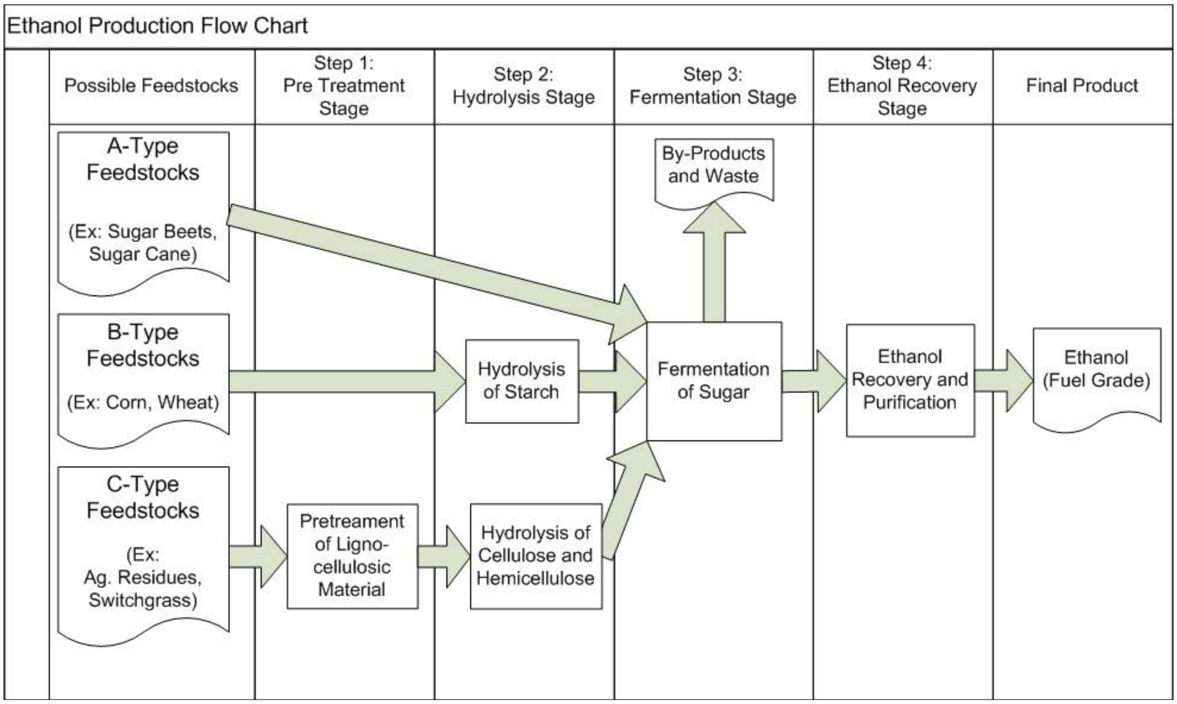

Figure 3-3: Schematic representation of ethanol production processes.

In addition to ethanol, there is a variety of other biofuels. Biodiesel, produced from vegetable oils or animal fats, is a distant second to ethanol in terms of production. In 2006, the United States produced approximately 225 million gallons of biodiesel (NBB 2006). Biofuels can also be produced through gasification of biomass using the Fischer-Tropsch process, and methane can be produced from plant and animal wastes. These methods, however, account for less than two percent of domestic production (WorldWatch 2006).

3.2 Stakeholder Landscape

Many stakeholders are involved in the biofuels debate, and their stakes are largely defined by their interactions with the biofuel production chain. Many have a direct financial interest in biofuel production; others have an indirect interest through competing products or representation of public interests. Agricultural suppliers, feedstock producers, ethanol producers, and fuel users are directly involved in the ethanol production chain. The food industry must compete with the biofuel industry for limited supplies of feedstocks, and the petroleum industry and producers of other substitute fuels compete with ethanol for market share. At all stages of the biofuel lifecycle, environmental and public health groups advocate for measures to mitigate the impacts of biofuel production and use on their constituencies. The stakeholders in the biofuels industry are mapped in Figure 3-4, and they are described in greater detail below.

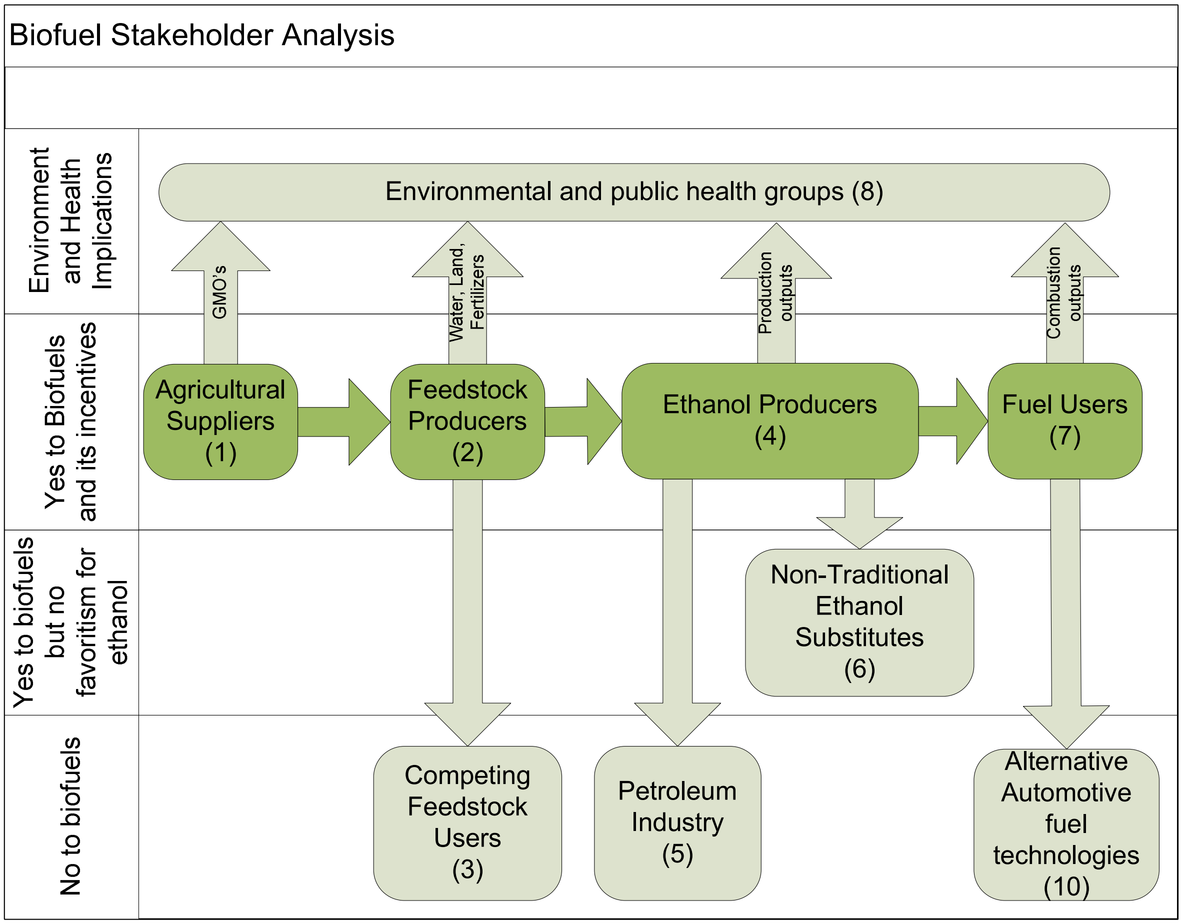

Figure 3-4: Stakeholder interactions with ethanol production chain.

1. Agricultural Suppliers

Agricultural suppliers provide chemicals, seeds, equipment and other necessary inputs to farmers. When the agricultural sector is strong, these companies benefit through greater demand for their products. In particular, seed companies like Monsanto benefit from high corn prices that increase demand for their proprietary crop varieties. Monsanto is expanding its capacity for engineered “triple stack” corn seed by 50 percent (Leckey 2007), and its share price nearly tripled between December, 2005 and December, 2007 (Yahoo 2007).

2. Feedstock Producers

Feedstock producers generate the raw materials for biofuel production. In the case of current biofuel production, the feedstock producers are farmers, and mainly corn farmers. As new biofuel technologies develop, the supply of feedstocks could diversify and farmers of other crops could join this group, as could those who own other sources of biomass, such as forest managers. These stakeholders benefit from biofuel production through increased demand for their products, and ideally would like to see sustained, predictable, and high demand for their products. Between 2005 and 2007, the average price received per bushel of corn increased by approximately $1.40 per bushel, indicating an increase in revenues of about $15 billion (assuming 11 billion bushels harvested), or an increase in revenues of nearly $200 per acre planted (USDA-NASS 2007).

3. Ethanol Producers

Ethanol producers are the core of the today's biofuel industry, converting corn into ethanol and co-products (primarily distiller's dried grains and solubles, or DDGS. DDGS are sold to feedlot owners for animal feed). As recently as January, 2007, farmer-owned co-operatives accounted for 39 percent of U.S. ethanol production capacity, but this share now stands at just 28 percent (RFA 2007). The ownership of the biofuels industry may be changing, but the fact remains that biofuel producers have a critical interest in seeing a robust and profitable market for biofuels. In the current market, it is estimated that ethanol producers may be collecting an annual windfall profit on the order of $4 billion, on top of ordinarily-expected returns.[2] The Renewable Fuels Association, the trade association for the ethanol industry, supports giving all biofuels equal treatment on a volumetric basis[3] and has argued against labeling of ethanol produced using best practices (Dineen 2006).

4. Competing Feedstock Users

The food industry relies on the same corn feedstock as today's ethanol producers. Those that rely on corn-based animal feed and corn syrup as a sweetener are particularly sensitive to the recent surge in corn prices. Increased production of biofuels from edible feedstocks will increase competition with food-chain uses of crops, against the interests of the food industry. It has been estimated that the demand of corn for ethanol production has already cost food consumers approximately $15 billion (Alexander and Hurt 2007; Tokgoz et al. 2007). Trade associations including the American Meat Institute and the Grocery Manufacturers Association oppose policies that favor the production of corn-based ethanol (Etter 2007), while a coalition of livestock producers has called for new mandates to target advanced, non-food biofuels, and for the elimination of tariffs on imported ethanol (Coalition for Balanced Food and Fuel Policy 2007).

5. The Petroleum Industry

The petroleum industry produces the conventional motor fuels that biofuels are intended to supplant. It is a vast and well-established industry, with revenues estimated to exceed $500 billion in the United States in 2007[4]. Biofuels compete directly with petroleum products, so increased biofuel use will come at the expense of petroleum use. The American Petroleum Institute (API) is a trade association for the petroleum industry and prefers to let the free market drive the adoption of biofuels, rather than to have policies that favor one fuel over another (Gross 2007). The API has stated that to the extent that they are compelled to include renewable fuels in their product mix, they prefer to have a uniform national standard that allows flexibility in compliance (Mannato 2006). The petroleum company ConocoPhillips has argued in support of allowing all biofuels, not just ethanol, to be counted towards renewable fuel obligations, and to be counted on an energy-equivalent basis rather than a volumetric basis (Benyshek 2006).

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[2] This assumes a yield of 2.7 gallons of ethanol and 17 pounds of DDGS per bushel or corn; a corn price of $3.50 per bushel, operating costs of $0.41 per gallon produced, capital recovery of $0.25 per gallon (capital cost of $1.57 per gallon of capacity, 20 year life, 15% discount rate) (Shapouri and Gallagher 2005), and a DDGS price of $0.055 per pound (Elam 2007), for a net production cost of $1.10 per gallon; 5 billion gallons of annual ethanol production; and $1.88 per gallon of ethanol, equivalent to $2.85 per gallon of gasoline, approximately the average gasoline price in 2007 (EIA 2007b).

[3] Note that ethanol contains approximately 30 percent less energy per unit volume than other renewable fuels, such as biodiesel or synthetic gasoline.

[4] Based on sales volumes and retail prices (excluding taxes) reported in EIA 2007b for the first nine months of 2007.

6. Non-Traditional Substitutes

Non-traditional substitutes include current and emerging alternatives to petroleum-based fuels and to ethanol. This includes other biofuels, methanol, hydrogen, and electricity. Biodiesel producers, suppliers of waste oils, and chemical producers have all supported incorporating energy content or lifecycle analysis into renewable fuel credits, rather than relying strictly on fuel volume (Lynn 2006, Parr 2006, Plaza 2006, Wellons 2006). In general, such calculations would provide their products with an advantage compared to ethanol. Additionally, developers of alternative powertrain systems and associated infrastructure, such as batteries for electric or hybrid electric vehicles, or hydrogen technology, have a similar stake in substituting their products for traditional petroleum-based systems.

7. Fuel Users

Biofuels are ultimately consumed by end-users who use them to fuel their vehicles. These end-users are primarily concerned with having an affordable and reliable supply of fuel for their vehicles, wherever they choose to travel. Consumers may have the ability to choose which fuel to put in a certain vehicle, or they may purchase a vehicle designed for dedicated use of a biofuel. Consumers with the ability to choose between petroleum fuels and biofuels will benefit the most from the competition between these options.

8. Environmental and Public Health Groups

The production and use of fuels imposes externalities on the natural environment and on the health of the population across most of the biofuel production chain, as discussed in section 4 of this report. The development of genetically modified organisms by agricultural suppliers creates concerns about contamination of the food supply and natural ecosystems by transgenic materials. Some farming practices consume a sizeable amount of water and fertilizer runoff from fields pollutes remaining supplies, while other practices may contribute to soil erosion and silting of waterways. Biofuels can help to cut global warming pollution, but these benefits are not universal. Environmental and public health advocacy groups attempt to minimize these effects by regulating the processes that create problems.

9. Government

While government has an obvious stake in keeping its constituents satisfied, it is also subject to several additional constraints that create a stake for it in the biofuels debate. In particular, the federal government is currently operating under a budget deficit, which according to the most recent official estimates will total $158 billion in 2007 (CBO 2007). This constrains the ability of the government to spend large quantities of money on subsidies or tax breaks for biofuel producers. Additionally, the federal government faces international pressure to open its markets to agricultural products from other countries. Maintaining tariffs or quotas on agricultural commodities and biofuels inhibits the government's ability to negotiate with other countries for access to their markets.

10. Automakers

Cars and light trucks consume more than 40 percent of the petroleum used in the United States (EIA 2007c). Manufacturers of these vehicles are under intense pressure to reduce the oil consumption and global warming emissions of their products. For the past decade, some automakers have made use of an incentive that gives them leniency in meeting federal fuel economy standards in exchange for producing vehicles that can use mixtures of gasoline and ethanol containing as much as 85 percent ethanol. It has been estimated that this incentive had saved manufacturers as much as $1.6 billion in avoided fines through 2005. However, these vehicles rarely use E85, running instead on gasoline most of the time (MacKenzie, Bedsworth, and Friedman 2005). Increased use of biofuels reduces the scale of the problem for automakers, helping them to deflect criticism and defuse political action on fuel economy. Automakers therefore have a stake in seeing the use of biofuels increase, but will likely be reluctant to make investments that facilitate this, unless they are compensated through continued incentives.

A summary of the stakeholders and their positions in the biofuels debate is presented in Table 3-1, below.

	Stakeholder	**Stake in Biofuel Industry**	**Major Positions**	**Examples**
1	Agricultural Suppliers	Crop seeds and specific fertilizers for their use	Yes to corn ethanol, yes to incentives. Prefer non-perennial.	Monsanto, Cargill
2	Feedstock Producers	Bigger market and higher prices for their products	Maintain subsidies, expand market. Prefer high crop prices	Corn (and other biofuel feedstock) farmers. American Farm Bureau Federation
3	Ethanol Producers	Ethanol is currently the dominant U.S. Biofuel	Yes to ethanol, yes to specific incentives.	Renewable Fuels Association, Archer Daniels Midland (ADM)
4	Competing Feedstock Users	Higher corn prices increase their production costs	Reduce subsidies for ethanol, reduce ethanol push, focus on non-food feedstocks.	Sweetener Users Association, American Meat Institute, Grocery Manufacturers Association
5	Petroleum Industry	Must blend fuels, resist larger percent mixes when prices are high.	Resistant to high blending requirements. Yes to subsidies. Want uniform national standards.	Exxon, BP and others, American Petroleum Institute.
6	Non-Traditional Substitutes	Compete against ethanol with different technology	Seeking more equitable treatment of their products in policy. Favor regulation based on energy content or life cycle analysis of fuel. May need alternative vehicle programs.	DuPont Lyondell Chemical Methanol Institute National Biodiesel Board Renderers Gasification companies Bio-FT companies
7	Fuel users	Want affordable and reliable supply of high quality fuel.	Support ethanol (as long as it is cheaper than gasoline). Prefer higher energy content fuels.	FedEx, UPS, Energy Security Leadership Council, general driving public

8	Environmental & Public Health Groups	Air quality Reduction in global warming emissions. Water quality. Soil quality Wildlife habitat Biodiversity	Better characterize air quality, effects of biofuels, safeguards against unintended consequences. Want better farming techniques.	EPA NESCAUM Environmental Defense National Wildlife Federation
9	Automakers	Reduced scrutiny and pressure to increase fuel economy. Optimal operation of engine emission control systems.	Favor continued biofuel production and incentives to produce biofuel-compatible vehicles. Favor standards for fuel quality.	Alliance of Automobile Manufacturers, Ford, GM, Toyota and others.
10	Government	Budget constraints, trade obligations, economic development.	Support ethanol because of its dual role in supporting a large constituency like corn growers, but also because it could reduce the foreign dependency of oil	Federal and State Government

Table 3-1: Summary of stakeholder positions in biofuels debate.

3.3 Current U.S. Policies Effecting the Ethanol Industry

Ethanol production in the United States is affected by agricultural as well as biofuel specific policies. There is an extensive history of legislation surrounding ethanol production dating back to the 1970s. A thorough history of this legislation is given in Appendix 1:.

More recently, the Energy Policy Act of 2005 has introduced several major initiative that have shaped the ethanol industry. The Renewable Fuels Standard (RFS) has set quotas for fuel supplies so that they are required to blend a certain amount of biofuel with conventional fuel each year. In 2006, 4 billion gallons were blended, and the requirement for 2012 will be 7.5 billion gallons. There are, however, fuel multipliers that give larger volume credits for some different types of biofuels. For example, each gallon of cellulosic and waste derived ethanol counts for 2.5 gallons toward meeting the obligations of the RFS (Tyner 2007).

The Jobs Creation Act of 2004 instituted a $0.51 per gallon tax credit to fuel blenders for each gallon of ethanol mixed with gasoline, and the tax exemption for ethanol was also extended through 2010.

Another major boost to ethanol was the phase out of methyl tertiary-butyl ether (MTBE) as an additive in gasoline due to growing concerns of groundwater contamination. While there was no national policy banning MTBE, several states had instituted bans, which led fuel supplies to use ethanol instead of MTBE beginning in the summer of 2006 (EIA 2006).

As ethanol transitions from being a fuel additive (less than 10 percent by volume) to being a gasoline replacement there are several barriers which other policies have addressed. Corporate average fuel economy (CAFE) standards include a multiplier that gives more mileage credits to vehicles that can run on blends with high ethanol content.

4 Goals and Trade-offs in Biofuel Development

The growth of the biofuels industry is creating a set of trade-offs between the expressed goals of environmental sustainability, energy security, and rural economic development, and is also contributing to rising food prices. Policies to date have largely focused on increasing biofuel production and have paid little heed to effects on food prices or the environment. Many of the conflicts arising from biofuel production are exacerbated by present day production methods, particularly the overwhelming use of corn as a feedstock. While there are emerging technologies that can help mitigate the problems, there are barriers to their entering the market. This section illuminates the key trade-offs between the goals of biofuel production, and section 5 identifies ways to balance conflicting interests and resolve these trade-offs.

4.1 Energy Security

One of the drivers behind biofuel production is energy security (Charles 2007). Energy security can be defined as the goal of reducing the economic risk to the United States of interruptions or severe price fluctuations in its energy supply. The ability of corn ethanol to contribute to energy security is limited, but advanced biofuels and the development of a more robust biofuels market can deliver greater security.

Biofuels can contribute to energy security even if they are not all produced domestically. In popular discourse, energy security if often conflated with energy independence, but the two need not be the same. Energy security can be improved by (1) reducing the economy's dependence on energy through greater efficiency, (2) increasing the diversity of fuel sources used, or (3) producing more fuels domestically. When consumers use energy more efficiently, they will be less vulnerable to fluctuations in energy prices. By diversifying fuel sources, consumers gain the ability to mitigate increases in the price of one fuel by switching to a different, less expensive fuel. A reliable supply of biofuels can complement the supply of petroleum-based fuels and alleviate the effects of oil price volatility. Producing fuels domestically can enhance energy security as well. While domestic energy prices are still influenced by fluctuations of the global market, increases in the price of domestically produced fuel create wealth transfers from consumers to domestic producers, rather than the loss resulting from payments to foreign producers.

In 2006, ethanol displaced 2.5 percent of the total gasoline consumption in the United States (EIA 2007b) but used 20 percent of corn production (USDA-NASS 2007), indicating that its capacity to substitute for petroleum is limited. Recent estimates suggest that as much as 10 percent displacement could be possible within 10-15 years (Groode 2007), contingent upon the deployment of some cellulosic ethanol capacity. If any biofuel is going to make the transition from fuel additive to alternative, it will be necessary to produce it using crops and processing methods that can deliver more gallons per acre of farmland than are realized with corn ethanol (Groode, 2007). An increase in domestic biofuel production to 10 percent of gasoline demand would be a significant achievement and could contribute to energy security goals, but would leave the United States well short of outright energy independence.

Energy security can be improved without achieving energy independence, through the development of a diverse range of fuel supplies that enhances the overall security of the supply system, even if the all of the fuel is not produced domestically. Increased use of biofuels can improve energy security by reducing vulnerability to oil price manipulation and by weakening the levers available to unfriendly regimes whose influence derives from petroleum wealth. That is to say, there is an energy security benefit to using foreign biofuels, because they are produced in different places and by different actors than petroleum. Thus, there is a trade-off between maximizing domestic biofuel industry profits through tariffs on imports and increasing energy security through greater total use of biofuels.

4.2 Ethanol and Food

Long before corn became a source of fuel in the United States it was a staple of the food system, and the recent surge in corn prices is generating a growing backlash from traditional corn users. Corn, corn oil, corn syrup, and other derivatives are basic ingredients in many US food products, and corn is also an important feed grain for poultry and livestock. Figure 4-5 shows the increase in corn prices over the past three years, corresponding with the boom in ethanol production shown in Figure 2-2. Increased prices for such a basic commodity have a ripple effect on products ranging from meat and dairy to soda. Increased corn prices are also drawing land away from the production of other crops, particularly wheat and soybeans. The cost of these effects has already been estimated at approximately $15 billion (Alexander and Hurt 2007; Tokgoz et al. 2007). The food industry is becoming increasingly vocal in its opposition to further increases in corn ethanol production (Etter 2007, Coalition for Balanced Food and Fuel Policy 2007).

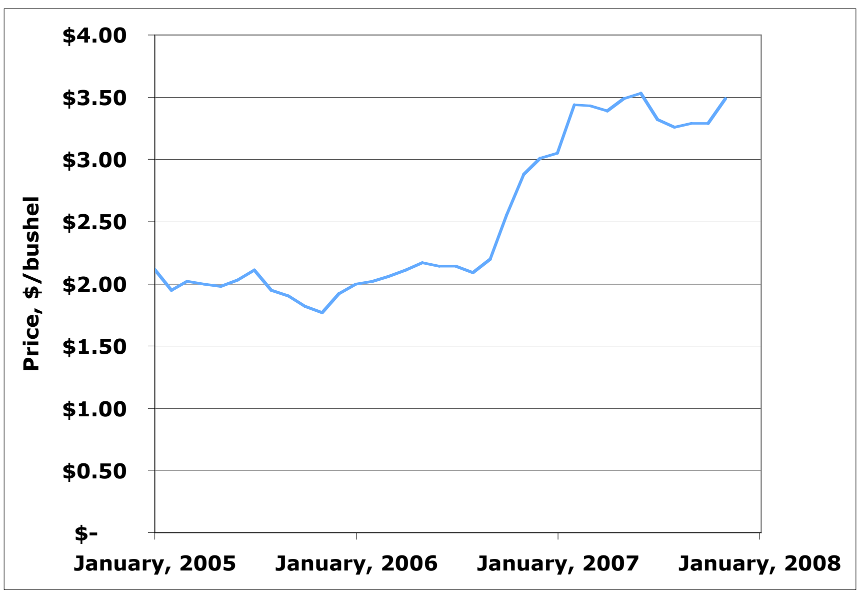

Figure 4-5:Corn Price Evolution (2005-2007) Source: USDA-NASS 2007.

Corn prices have increased by approximately $1.50 per bushel since 2005

Rising prices for basic food supplies has implications for U.S. interests internationally as well. Recent increases in world food prices are partially, though not entirely, attributed to increased grain demand for ethanol. Such increases are also caused in part by increased wealth and demand for food. However, the United Nations has identified world food prices and biofuel production from food sources as an important challenge (Harrabin 2007). In an environment of rising food prices, turning food into ethanol and burning it may attract criticism that undermines international relations.

4.3 Global Warming Pollution

Reduction of global warming pollution is a commonly cited benefit of biofuels, but current corn ethanol actually reduces global warming emissions by less than 20 percent relative to gasoline (Groode 2007). Ethanol conversion facilities require substantial inputs of fossil energy, and corn farming releases significant amount of global warming pollution. It is not clear if new biofuel development would actually be beneficial to the environment, because the environmental impact and climate change effects are strongly dependent on the characteristics of the crops grown, the method of cultivation, and the fuel used to power the conversion facility. (Groode 2007, Farrell et al. 2006). Furthermore, increased demand for corn may be eroding what little global warming benefit corn ethanol offers.

Corn ethanol conversion facilities require substantial inputs of fossil energy, primarily to provide the energy for distilling the watery fermentation product. Whether this energy is provided by coal or natural gas can make the difference between ethanol that produces a modest reduction in global warming emissions, or a small increase in emissions (Farrell et al. 2006).

In addition to the global warming pollution generated during ethanol processing, corn ethanol production generates substantial emissions of nitrous oxide during corn farming. The use of nitrogen based fertilizers leads to the production of nitrous oxide, a potent global warming pollutant. According to the EPA, the potency of nitrous oxide as a greenhouse gas over a 100-year timeframe is more than 300 times that of CO_2 (EPA 2006a). Approximately 74 percent of U.S. nitrous oxide emissions arise from agriculture, primarily from the application of synthetic fertilizers and livestock manure (Greenhalgh and Sauer 2007). This creates an important trade-off between global warming emissions and ethanol production: as corn demand increases, farmers try to squeeze more bushels out of every acre, fertilizer application rates increase, which erodes the global warming benefit of the ethanol.

The forthcoming thesis by Groode examines uncertainties in the expected benefits or ethanol and evaluates lifecycle emissions in various scenarios (Figure 4-6). Groode finds that there is a range of probable global warming benefits depending on region and processing practices as well as the assumptions used. It finds that ethanol produced from corn grown in Iowa delivers modest global warming benefits if a co-product credit is assigned, but ethanol made from corn that was grown in less ideal regions (such as Georgia) could actually generate higher global warming emissions over its full lifecycle than gasoline does (Groode 2007). Thus, greater demand for corn due to corn ethanol production could lead to corn being produced in regions where greater fertilizer and energy inputs are required, further eroding the benefits of corn ethanol.

Advanced biofuels, such as cellulosic ethanol, may help to address these trade-offs, because cellulosic ethanol is expected to deliver much greater reductions in global warming pollution. Cellulosic feedstocks do not require as much nitrogen fertilizer application, and the non-fermentable portion of the feedstock can be recovered and burned to provide the heat needed to drive the fermentation and distillation process. Cellulosic ethanol could deliver a lifecycle global warming emission reduction on the order of 90 percent compared with gasoline (Farrell et al. 2006).

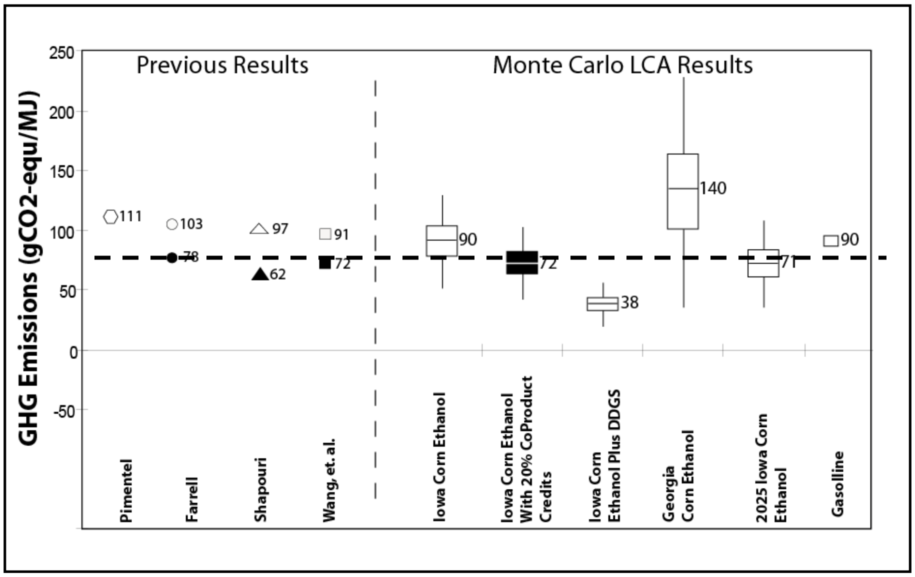

Figure 4-6: Ethanol and Greenhouse Gas Comparison. Source: Groode 2007

Global warming emission benefits of corn ethanol vary from negligible to modest, depending on how it is made. The dashed line indicates gasoline global warming emissions.

4.4 Local and Regional Environmental Impacts

The agricultural industry faces many known environmental issues, most prominently nitrogen fertilizer runoff, water intensity, erosion, soil quality degradation, and ecosystem destruction. This section addresses the issues of soil degradation and ecosystem destruction, and section 4.5 addresses water-related issues.

4.4.1 Soil Quality

Soil quality is threatened by changes in agricultural practices that result from increased ethanol demand. In traditional corn growing practices, farmers rotate fields of corn and soybeans in order to maintain soil quality naturally. Soybeans act as natural nitrogen fixers, reducing the need for nitrogen fertilizers. However, with the increase in corn prices, farmers are shifting away from the soybean crops (Figure 4-7), leading to decreased soil quality. This not only increases the price of soybeans, but also increases the use of nitrogen fertilizers to compensate for the lack of nitrogen-fixing by the soybean crops. This exacerbates the environmental damages associated with nitrogen fertilizer application, as discussed in sections 4.3, 4.5, and 4.6.

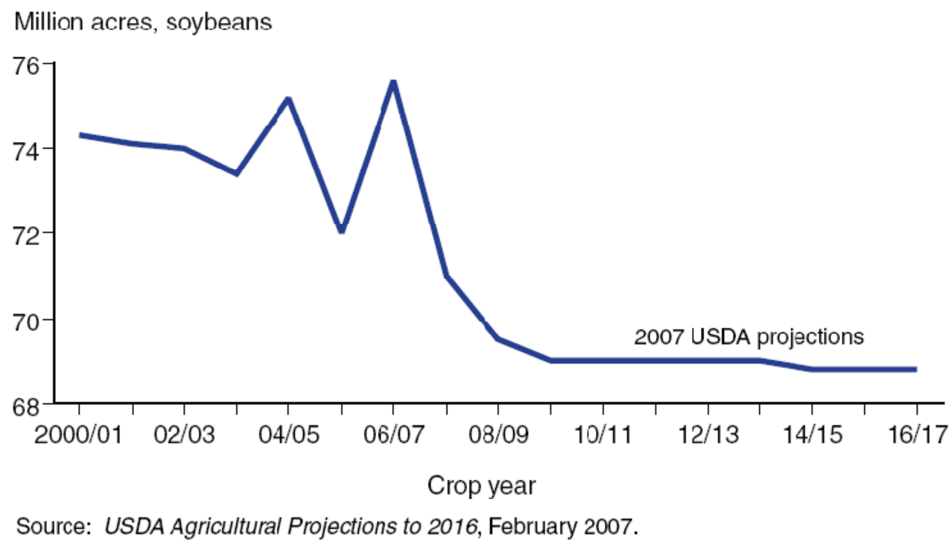

Figure 4-7: Projected drop in soybean acres due to reduced rotation. Source: Westcott 2007.

A further complication for soil quality comes from the removal of agricultural residues from fields. Residues are the parts of the plant left on the field after harvest, such as corn stover. These residues help prevent erosion, and ultimately biodegrade and restore nutrients to the field. However, they also present a ready source of cellulose-rich plant material that is attractive as an interim feedstock for the production of cellulosic ethanol or other biomass fuels. A serious push for cellulosic biofuels would likely lead to the removal of agricultural residues, but it is currently unknown what fraction of stover may be removed from the field without reducing on long-term soil quality (Tilman 2006). Therefore, although cellulosic biofuels would help prevent soil quality reductions due to over-production of corn, they introduce a new risk for soil quality.

4.4.2 Ecosystem Preservation

Ecosystem preservation faces strong challenges in the current environment. Increasing land prices (Figure 4-8) diminish the incentives to remove land from production through the Conservation Reserve Program or other programs. In a bid to rapidly increase production, invasive species have also been suggested as energy crops (Raghu 2006). Invasive species represent a direct threat to existing ecosystems, because they upset the equilibrium between native species. As discussed in the next section, there is also an increased risk to aquatic habitats from agricultural chemical runoff.

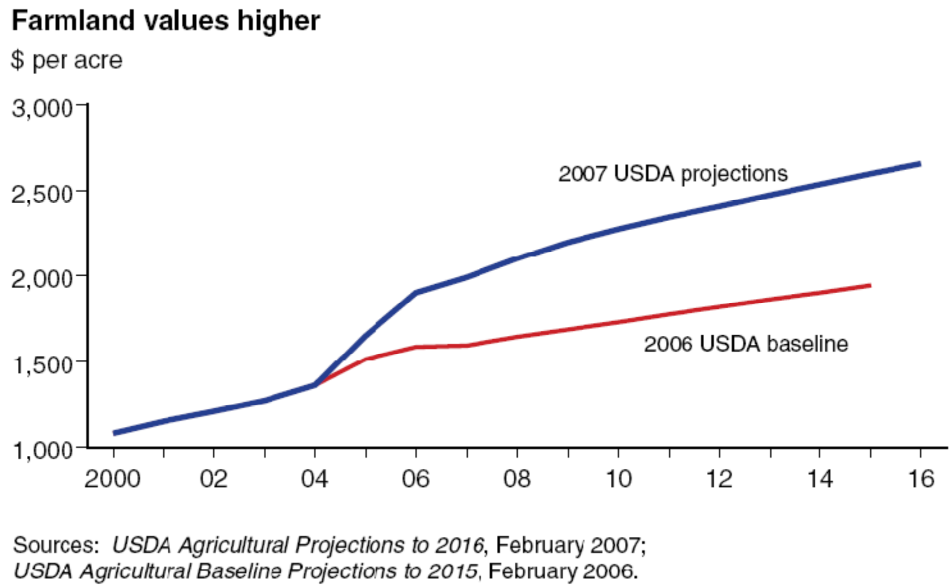

Figure 4-8: Farmland Value Projection. Source: Westcott 2007

4.5 Water Impacts

The impacts of agriculture on water resources fall into three main categories: soil erosion, depletion of water resources, and chemical runoff from fields. Because of regional differences, the scale of these impacts is not uniform around the country.

Soil erosion is a concern not only because it accelerates nutrient loss through topsoil erosion (as discussed in section 4.4.1, but also because it impairs water quality by introducing sediments into waterways (NAS 2007). In 1993, the USDA estimated that cropland erosion accounted for approximately half of the sediment that reaches US waterways each year (NAS 2007). This erosion is exacerbated by row cropping systems which lead to higher erosion rates than constant cover crop system (NAS 2007).

The depletion of water resources is a serious concern in many areas of the United States. Water levels in groundwater aquifers, such as the vast Ogallala aquifer beneath the plains states, have decreased dramatically (NAS 2007). Recent drought conditions in the southeast have also served to highlight water scarcity and constraints on local use. However, water intensity varies by region, crop, and cultivation methodology. For example, the amount of water required to irrigate corn varies by more than a factor of 10 across the United States, as shown in Figure 4-9. Some regions are much better suited than others to the production of certain crops, which highlights the key problem associated with favoring biofuel production from a certain crop: such favoritism will lead to that crop being produced in regions where other crops might be more suitable.

Increased chemical runoff due to irrigation leads to both short- and long-term environmental and health issues (see section 4.6 for a summary of the health impacts). The two major environmental effects of nitrogen use are hypoxic zones and elevated global warming pollution (global warming pollution is discussed separately in section 4.3). Hypoxia is a condition in which the dissolved oxygen content of water is too low to support life. It is fueled by nitrogen runoff into water systems, which facilitates overgrowth of algae. When this algae decomposes, it depletes oxygen in the water. Two major hypoxic zones, otherwise known bluntly as “dead zones,” are located in the Chesapeake Bay and Gulf of Mexico (Figure 4-10). A 2007 National Academies report estimated that agriculture is responsible for 65 percent of the nitrogen and 74 percent of the nitrate loads in the Gulf of Mexico (NAS 2007). If current production methods continue, the increased stresses brought on by higher corn demand will only exacerbate the situation, especially as fertilizer application rates increase in response to greater corn planting (see section 4.4.1).

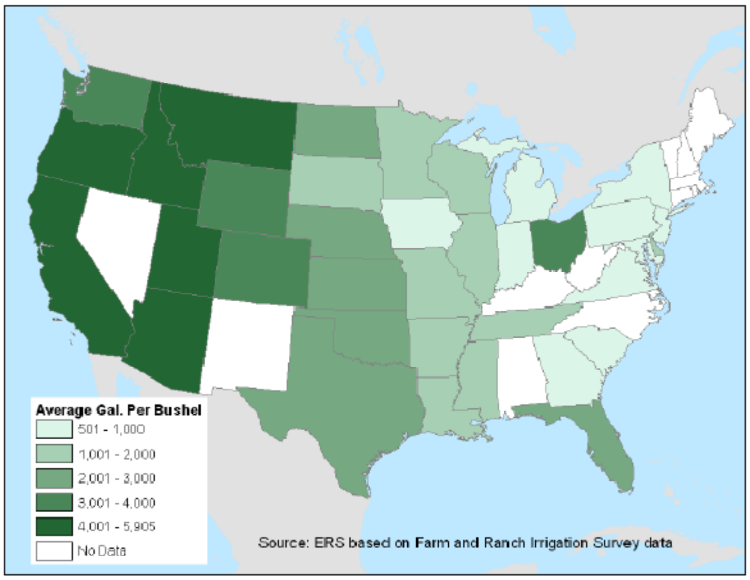

FIGURE 2-2 State-by-state water requirements in 2003 of irrigated corn (gallons of irrigation water per bushel). SOURCE: N. Gollehon, USDA ERS, written commun., July 12, 2007. Based on data from 2003 Farm and Ranch Irrigation Survey (USDA, 2003).

Figure 4-9 Source: NAS via ERS. Darker colors indicate more water use.

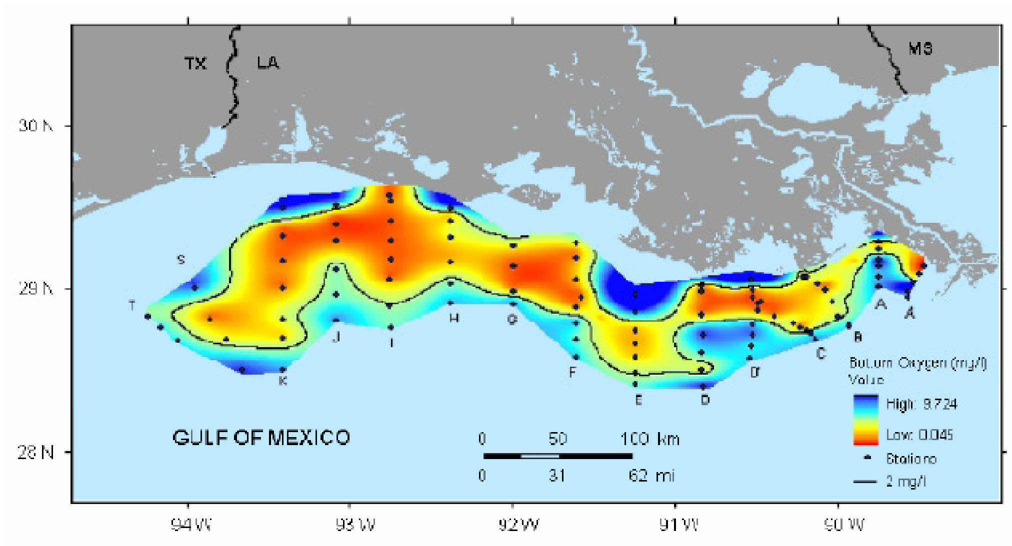

FIGURE 3-3 Dissolved oxygen contours (in milligrams per liter) in the Gulf of Mexico, July 21-28, 2007. SOURCE: Slightly modified from http://www.gulfhypoxia.net/shelfwide07/PressRelease07.pdf. Reprinted, with permission, from N. Rabalais, Louisiana Universities Marine Consortium.

Figure 4-10: Hypoxia in Gulf of Mexico. Source: NAS via ERS.

Red colors indicate low oxygen content.

4.6 Local and Regional Health Impacts

Fertilizers, pesticides, and herbicides all have links to environmental and human health issues. Both excess nitrogen and phosphorus have been identified as affecting drinking water quality (NAS 2007). Excess nitrates in the water supply cause short-term health effects such as decreased oxygen carrying capacity in blood, and can lead to longer-term effects including interference with urine production and hemorrhaging of the spleen (EPA 2006b). Of the other pesticides and herbicides, atrazine is the most controversial. Atrazine is used as herbicide, and although it is used in relatively small quantities, there have been some studies linking its use to mutations in embryonic development (Taets et al. 1998). Figure 4-11 shows the regions that are most at risk for atrazine runoff in the United States. The areas most at risk are generally those associated with corn production.

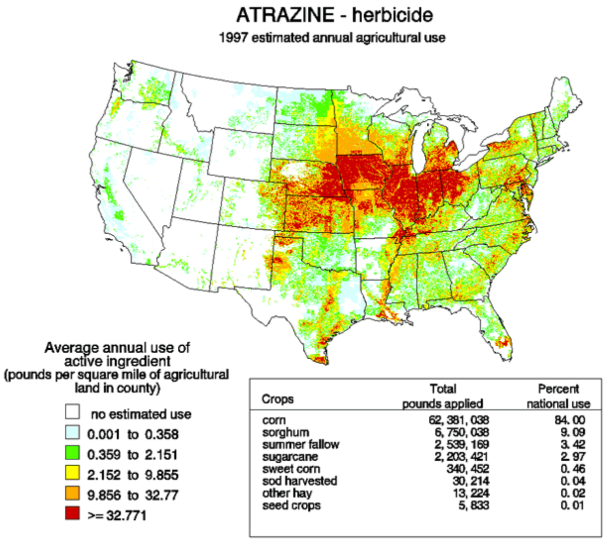

Figure 4-11: Regions of potential risk of atrazine runoff.

Source: http://oceanworld.tamu.edu/resources/oceanography-book/Images/atrazine-use-1997-map.png

4.7 Policy Mechanisms and Political Feasibility

Consideration must be given to the policy tools chosen to drive change in the biofuel industry. Policy is only effective if it can pass the legislative process, and tradeoffs in the political process can be driven by ideology on the role of government and appropriate forms of market intervention. Issues of taxation, spending, industry support, and "picking winners" can be especially contentious.

4.7.1 Taxes or Subsidies

Taxes or subsidies can have the same effect on the market, but subsidies tend to be more popular with the group being targeted by the policy. Subsidies can impose a significant cost on the government, and this cost must be offset with taxes on other sectors. Agricultural subsidies and blender tax credits have been pivotal in supporting the growth of the biofuel industry to date, but the blender tax credits alone are on the order of several billion dollars annually. In general, substantial fuel tax increases have been all but impossible politically in the United States.

4.7.2 Development Support or Industry Dependency

Policymakers must find a balance between encouraging growth in emerging industries and making those industries dependent on continued government support. As tax credits spur growth in the ethanol industry, it will become increasingly burdensome for the government to fund these endeavors. At the same time, it will become ever more challenging to remove supports from a politically powerful interest group. In an environment of continued high gasoline prices, biofuels should be able to succeed on their own. However, if gasoline prices were to fall, subsidy removal could prove disruptive to an increasingly important segment of the economy.

4.7.3 Defining Goals or Pushing Solutions

Policies can be crafted either to achieve a certain goal or to advance a particular solution. Targeting a particular technological solution may seem easier, and such an approach can be tempting because the technology in question provides the comfort of a concrete solution. However, this approach of "picking winners" has the side effect of also making losers of other technologies that might otherwise succeed. In the long term, policies will be most effective if they define a clear goal and create the regulatory environment in which potential solutions can compete with one another. While ethanol currently dominates the US biofuel market, it has many adverse effects, and there are many competing technologies with the potential to address its shortcomings. Policies should create a level playing field for all solutions to the challenges of energy security, economic development, and environmental sustainability.

5 Developing Policies for the future of Biofuels

After evaluating the current and likely continued effects of agricultural development for biofuels, it is essential to look forward with some goals in mind. The development of alternative fuels is typically justified as an environmentally friendly option that will increase security of supply and stimulate domestic industry. Due to the complex network of trade-offs these goals have not been effectively addressed with the current biofuel system. New policies are required to ensure the development of environmentally friendly fuels that are also economically viable.

The ultimate goal of biofuel policy should be a sustainable open market. A sustainable market should be international and environmentally responsible. In order to achieve these goals, a forward-thinking framework must be put in place to establish stable markets and supports for agricultural best practices. It is critical to begin implementing these programs now because future technological development remains uncertain. Some policy initiatives are preparatory and must therefore come before others. The policy strategy that follows is laid out in three phases (Figure 5-12).

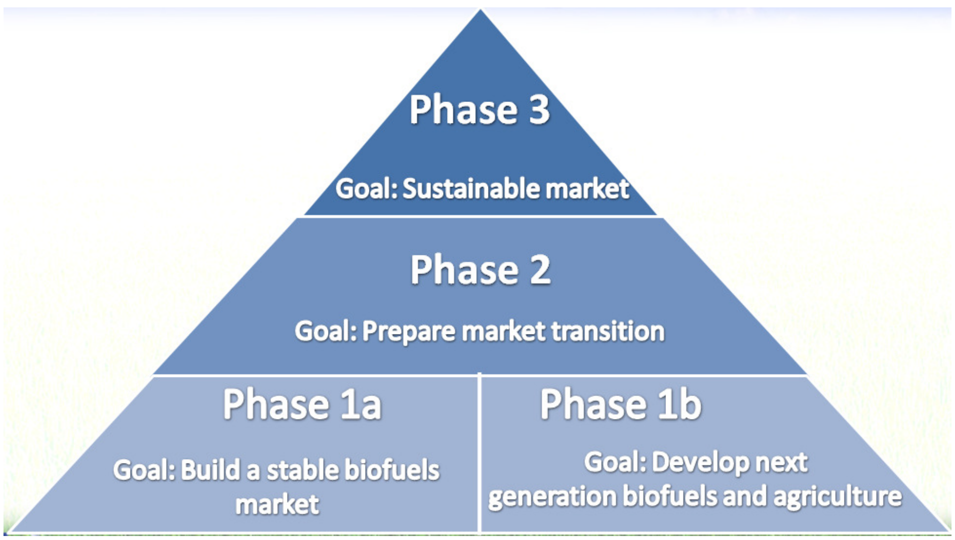

Figure 5-12: Three phase policy strategy

5.1 Phase 1a: Building a Stable Biofuels Market

The goal of this phase is to reduce risk for ethanol producers and develop a market for advanced biofuels. Currently, the petroleum industry dominates the transportation fuels market; there are established distribution networks and a largely single-fuel vehicle fleet. New entrants to the fuels industry therefore face two major challenges:

1. **Competing on the price of oil**: New fuels will initially hold small market share and must compete as price takers. The price of oil is volatile, and the viability of new entrants fluctuates with oil price. Without a baseline price, there is a significant risk that fuel price will drop, naturally or artificially, and that new entrants will no longer be profitable.

2. **Fuel Demand**: In small volumes, ethanol and other biofuels can blend as identical replacements. With increased blend percentages, current vehicles and fuel distribution networks cannot be used.

In order to mitigate these risks, this report proposes four policies. The first policy, a pro-competition petroleum price backstop, would prevent artificially depressed oil prices and provide a stable competitive environment. The second two policies, flex-fuel vehicle production and infrastructure support, address fuel demand and allow the industry to grow.

5.1.1 Fuel Price Backstop

Policy Definition

An ideal situation would be one in which the production and distribution costs of advanced fuels were permanently and predictably reduced to less than the equivalent costs of gasoline. However, such an ideal situation is unlikely to occur in an unregulated market because petroleum prices are extremely volatile, and if alternatives did gain significant market share, the price of petroleum would drop in response. A variable tax that decreases as the price of oil increases will reduce the ability of petroleum producers to lower prices below a certain level. This prevents monopolistic behavior designed to eliminate competition. Additionally, a variable tax should not affect consumer prices unless oil prices fall considerably.

Background

During the development stages of the biofuel industry, biofuels will be price takers from the oil industry. While the price of oil is high, all alternative fuels have a better chance of being cost competitive; however, if the price of oil falls below the production cost of alternatives, then the alternatives will lose significant market share. It is conceivable that if a group with market power, such as the Organization of Petroleum Exporting Countries (OPEC) sees ethanol as a serious substitution threat, it could lower the world price of oil for just long enough to cause this disruption.

In today's market gasoline prices are relatively high, a result of crude oil demand growth outpacing supply increases. However, crude prices – and by extension, gasoline prices – are volatile (Figure 5-13) and could easily drop below current levels as new sources of conventional or synthetic petroleum are brought online.

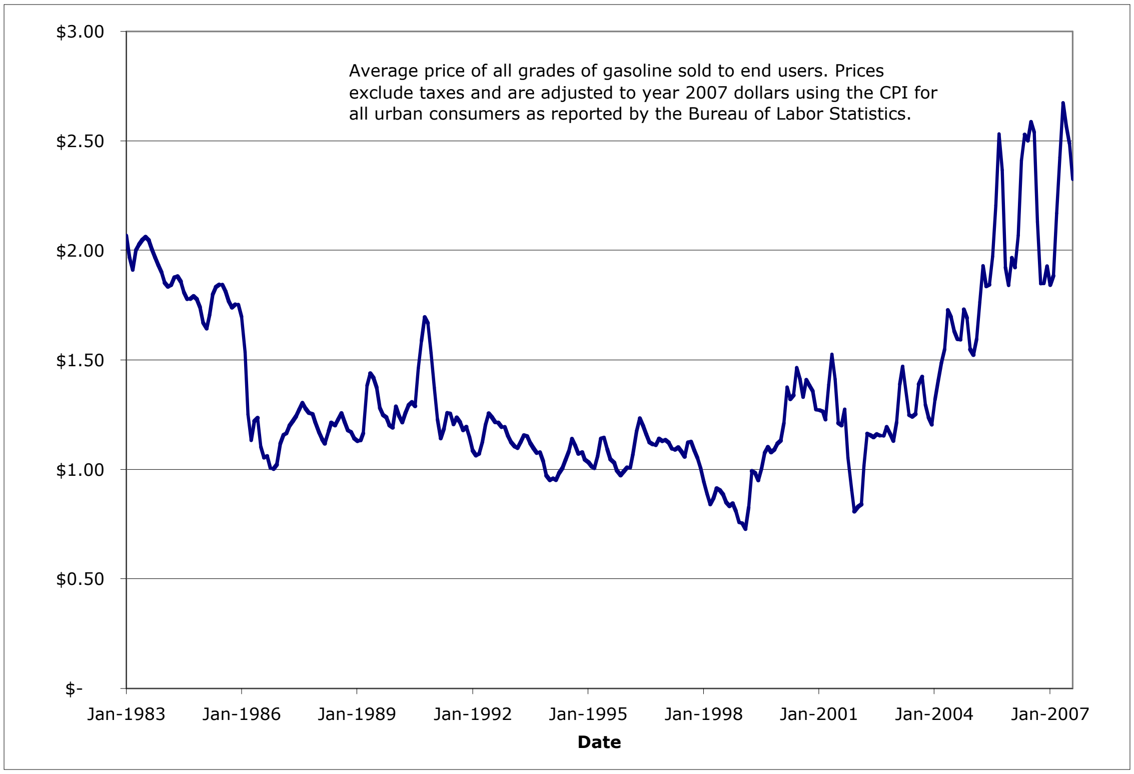

Figure 5-13 Average price of gasoline to end users, excluding taxes (EIA 2007b). Prices are adjusted to year 2007 dollars using CPI for all urban consumers (BLS 2007).

Ethanol would no longer be price competitive if gasoline prices fell dramatically. For example, the capital and operating costs associated with corn ethanol production – which include DDGS revenues but exclude feedstock costs – are estimated to be $0.36 per gallon (Tokgoz et al. 2007) or $0.54 per gasoline-gallon equivalent (GGE). Including the feedstock costs , at modest corn price of $2.00 per bushel increases the cost of corn ethanol to approximately $1.61 per GGE. For cellulosic ethanol, optimistic capital and operating cost estimates are $0.97 per gallon (Tokgoz et al. 2007), or $1.46 per GGE. Adding a feedstock cost of $35 per ton at a conversion rate of 100 gallons per ton increases the cost of cellulosic ethanol to approximately $2.00 per GGE. Therefore, if the price of gasoline fell below $1.50 per gallon, neither current nor advanced ethanol would be able to compete.

Compounding the pricing problem is the fact that the price of crude oil is determined by the cost of production at the margin. In other words, the cost of oil depends on the production cost for the last and therefore most expensive barrel that comes out of the ground. As a result, displacing a fraction of petroleum with biofuels will displace this most-expensive oil. This will have the effect of lowering the price of the remaining oil, making it that much more difficult for biofuels to be cost-competitive. In effect, biofuels will become victims of their own success should they ever succeed in displacing a significant quantity of oil.

Farmers and prospective ethanol producers are aware of these challenges and will be reluctant to make major investments in ethanol plants or dedicated energy crop production. This will be true until they are confident that there will be a stable and profitable market for biofuels, therefore, for biofuels – or any alternative fuels –to develop market share, there must be some certainty in terms of their price competitiveness with gasoline.

The simplest way to alter the balance between gasoline and ethanol is to reduce the effective cost of ethanol through subsidies. This is currently done through the $0.51 per gallon blender tax credit. While this policy has been successful for growing the ethanol market to date, it is no longer suitable for continued growth for several reasons. (1) The tax credit applies only to ethanol and not to other renewable fuels. (2) The uniform credit does not account for the environmental impact of the fuel; low-carbon, advanced cellulosic ethanol is eligible for the same credit amount as corn ethanol produced in a coal-fired conversion plant. (3) The credit does not vary with the price of fuel. If gasoline prices drop below $1.00 per gallon, ethanol is not an attractive investment, even with the tax credit. But in the current environment, with gasoline well over $2.00 per gallon, ethanol is profitable even without the tax credit. As a result, the current tax credit is inadequate to provide a secure market for ethanol when the price of gasoline is low, yet costs the government billions of dollars unnecessarily when the price of gasoline is high.

Detailed Policy Description

An alternative way to address the risk of deflated oil prices undermining the market for biofuels is to restructure taxes on gasoline or crude oil.

One mechanism is a price floor, like that proposed by Senator Richard Lugar. Lugar proposes a hard price floor of $35-45 per barrel (Lugar 2006a, Lugar 2006b). A hazard of the price floor is that producers would simply to set their prices at $35, even when market conditions would set a lower price. Oil purchasers would be indifferent to the distribution of cost between producers and government as all they would see is a $35 price tag. As a result, oil producers would earn enormous profits from such a proposal if the market price of oil dropped below $35 per barrel. Because such a system could lead to a large transfer of wealth to oil producers – some of whom are unfriendly to the United States – this policy would fail to address the security goals that are key drivers of the biofuels push.

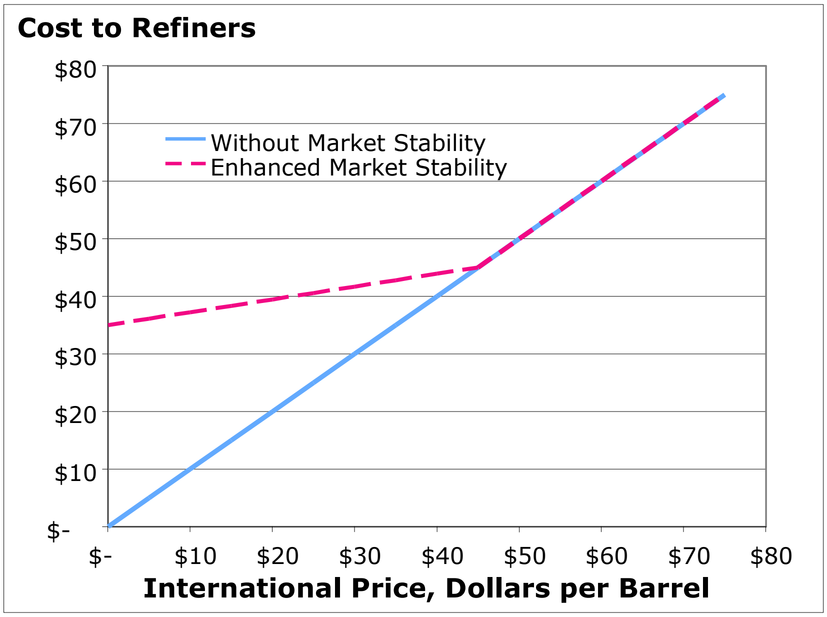

Figure 5-14: Oil prices with and without a "price floor."

A variable levy on oil purchases could prevent the price of oil from dropping extremely low, thus mitigating the risk of oil market volatility

A more refined concept of the price floor is a variable levy that decreases as the price of oil increases. For example, the tax could be set to $35 per barrel when the price of oil is zero, and decrease linearly to zero when the price of oil reaches $45 per barrel (Figure 5-13). This would moderate the effects on consumers when prices are high, while still giving oil purchasers an incentive to bid down prices even when prices are low, minimizing the transfers of wealth to unfriendly producers and diverting the money instead into government coffers. The effect of such a policy on gasoline prices is illustrated in Figure 5-15. Even if crude prices plummeted, the price of gasoline would remain above the $1.40-$1.50 per gallon level, helping to keep biofuels competitive. At prices greater than the minimum required for biofuels to remain competitive, however, the tax would disappear. In this way, consumers would not be unduly burdened when fuel prices are already high and biofuels competitive.

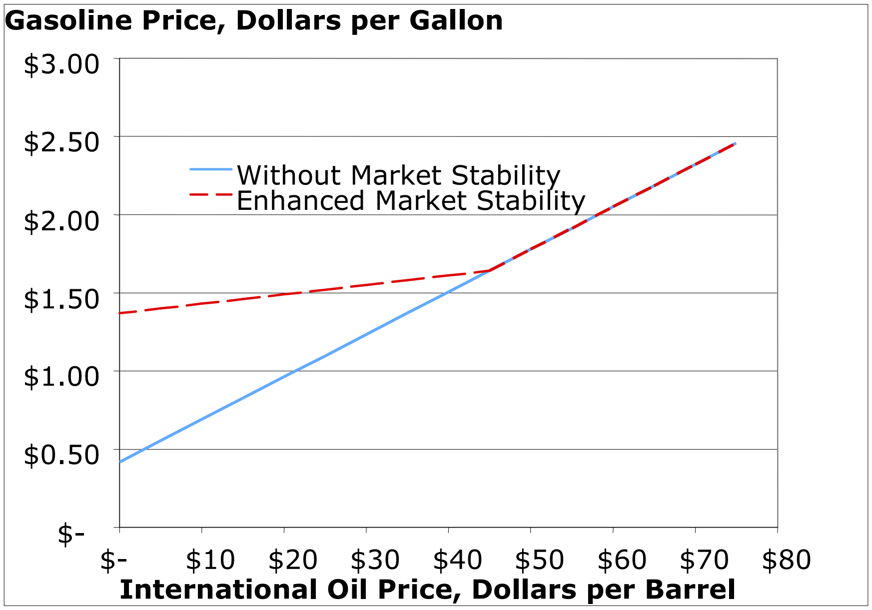

Figure 5-15: Gasoline prices with and without a "price floor" market stabilization mechanism.

5.1.2 Flexible-Fueled Vehicles

Policy Definition

To create a large and predictable market for higher biofuel blends, the number of flexible-fuel vehicles (FFVs) on the road needs to be significantly increased. An existing incentive program has been effective for introducing limited numbers of FFVs into the vehicle fleet (MacKenzie et al. 2005); however, the FFV production incentive should be restructured to reduce the per-vehicle credit and increase the number of FFVs on the road.

Background

Most vehicles on the road– and all new gasoline vehicles sold – in the United States are warranted by the manufacturer to use up to 10 percent ethanol by volume in their fuel, a blend known as E10 (Ethanol Facts 2007). However, in order for ethanol to displace more than 10 percent of gasoline volume (i.e. more than about 15 billion gallons per year; EIA 2007b), a portion vehicles would need to burn fuels containing more than 10 percent ethanol. Flexible-fueled vehicles (FFVs) are vehicles that are designed to operate on any mixture of gasoline and ethanol from pure gasoline up to 85 percent ethanol by volume (E85). About 6 million FFVs are already on the road (NEVC 2007), and it is estimated that the incremental cost of an FFV is about $100 over an identical gasoline-only vehicle (Kahn Ribeiro 2007). Although the presence of 6 million FFVs on American roads demonstrates that the flex-fuel technology is mature, the vehicles are too dispersed among the more than 200 million cars and light trucks on the road to sustain a broad E85 fueling infrastructure (since the vehicles do not require E85, they generally use gasoline).

Detailed Policy Description
The FFV incentive program should be redesigned to increase the number of FFVs produced. Currently, FFVs are assigned an approximately 65% extra credit toward meeting Corporate Average Fuel Economy (CAFE) standards. For example, a Chevrolet Tahoe FFV with a test fuel economy of 18 miles per gallon (mpg) on gasoline is credited with 30 mpg for purposes of determining compliance with CAFE standards (MacKenzie et al. 2005). To increase the number of FFVs, the fuel economy bonus credit should be reduced from 65 percent to 20 percent. This would require automakers to produce more FFVs in order to get the same improvement in overall credited fuel economy. Based on the mix of vehicles sold in the United States in model year 2003, reducing the bonus credit in this way would approximately double the number of FFVs sold, if the credit cap were maintained at 1.2 mpg (MacKenzie et al. 2005). This would accomplish the goal of increasing the market for E85 without undermining energy security and environmental goals through greater petroleum use.

5.1.3 Infrastructure development for biofuel distribution

Policy Definition
Continue and expand EPACT 2005 funding for alternative fuel infrastructure.

Background
A critical growth factor for biofuels will be a distribution network. Corn production is primarily in the Midwest, but major population centers are located on the coasts. Trucking is costly, inefficient and adds greenhouse gasses to the life cycle of the fuel. Rail networks represent a better alternative to trucking, and are more politically feasible compared to dedicated pipelines, because no new infrastructure is required. Gasoline filling stations will also have to adapt to have separate tanks to accommodate more corrosive ethanol-rich blends. This is a significant cost for gas stations, which will likely need to see a market and either a mandate, tax or subsidy incentive to drive them to invest in infrastructure.

Funding of refueling stations is already granted tax credits by the federal government. Section 1342 of the Energy Policy Act of 2005 (EPACT 2005) provides tax credits for up to 30% of the cost of alternative refueling stations. The alternative fuels included in the legislation are: natural gas, propane, hydrogen, E85, and biodiesel blends of B20 or more.

Detailed Policy Description
Infrastructure tax credits from EPACT 2005 should be renewed and expanded. Tax credits should be extended to other alternative fuels such as Fischer-Tropsch fuels. Credits should also be extended to other required infrastructure investments such as pipelines.

5.1.4 Stakeholder Response

A summary of stakeholder positions regarding the policy initiatives is given below in Figure 5-16. It is expected that the petroleum industry will oppose all of the proposed measures in Phase 1a; this is not unexpected for policies establishing market competition. Competing feedstock users are also unlikely to support the proposed policies. During this phase, is expected that most ethanol will be produced from corn and therefore will continue to produce a food versus fuel trade-off. These proposals should, however, garner considerable support from agricultural suppliers, feedstock producers, and ethanol producers. This brings a strong ally in the substantial agricultural lobby in favor of implementation.

While this early phase does not help move away from corn ethanol, it does ease market entry for better forms of ethanol. New industries need risk reduction in order to make investment more appealing. The fuel price backstop will help achieve this goal, while flex fuel vehicles will demonstrate an accessible market. There is a threshold of vehicle penetration that, once reached will make it easier for fuel companies to sell higher blends of ethanol. To facilitate this transition a new network for transporting fuel must be developed. Transitions of this magnitude are not often well received by industries that have adapted to their current business environment. However most stakeholders are expected to reap benefits from the implementation of these policies. A more complete description of expected stakeholder responses can be found in Appendix 3.

		Final Stakeholder Analysis			
		Phase 1A			
		Policy Objective: Building a Stable Biofuels Market			
	Stakeholders / Specific Policy Tools:	Fuel Price Backstop	Incentieves for flex fuel vehicles	Infrastructure development incentives	
1	Agricultural Suppliers	↑	↑	↑	
2	Feedstock Producers	↑	↑	↑	
3	Competing Feedstock Users	↘	↓	↓	
4	Ethanol Producers	↑	↑	↑	
5	Petroleum Industry	↓	↘	↘	
6	Non-Traditional Ethanol Substitutes	↗	↓	↘	
7	Fuel users	↘	↑	↑	
8	Environmental & Public Health Groups	↑	↑	↗	
9	Automakers	↗	↘	→	
10	Government	↗	↘	↘	

Figure 5-16: Summary of Stakeholder positions regarding Phase 1a

5.2 Phase 1b: Fostering Next Generation Biofuels and Agriculture

The goal of this phase is to develop the biomass collection, biomass processing and agricultural techniques required to produce sustainable next generation biofuels. Sustainable biofuels address the food versus fuel dilemma as well as environmental implications.

Current production methods will not be able to displace large amount of petroleum. Additionally, as discussed in the above trade-offs, today's corn ethanol production does not adequately address food prices or environmental consequences. Therefore, to achieve a full scale sustainable biofuel industry in the United States, cellulosic biomass feedstocks must be developed.

This report recommends three distinct areas for research: conversion technology, biomass collection, and agricultural methods.

5.2.1 Advanced Conversion Technology

Policy Definition
Continue and expand biofuel conversion technology research and development. This report recommends the federal government to continue to fund national laboratory research, university research, and pilot plants.

Background
The key to solving many environmental problems will be the process technology for converting feedstocks into fuel. A biofuel system becomes more easily scalable as the feedstock specificity of the conversion technology decreases. For example, cellulosic feedstocks offer many benefits over traditional crops in terms of cultivation requirements; however, this technology is not currently cost competitive. Further development of this technology will, however, allow for a decrease in feedstock specificity as many different sources such as corn stover, sugarcane bagasse and cereal grain straws all can be used as primary energy sources, and as such this technology is easily scalable over many different agricultural regions.

Detailed Description
There are several government agencies that are involved in investment for advanced biofuel development. National research laboratories are often large recipients of funding for advanced technology, several of which have programs to address technological challenges of biofuel processing.

Research funds are allocated to many institutions, including universities and private R&D firms. This diverse approach is appropriate to cover advancements that are required from basic science to commercial scale implementation. The specific balance of allocation necessary is outside the scope of this report, but funding should be spread among feedstock development, microbial breakdown, gasification and thermal breakdown, waste processing, and pilot plant financing

The Department of Energy announced plans to invest $375 million in three new biofuels centers between 2008 and 2013. This research will be primarily devoted to the biological methods of breaking down cellulosic feedstocks for biofuel production (DOE 2007a). “Biomass to Liquids” is another program that will focus more on gasification and thermochemical synthesis of advanced biofuels (DOE 2007b). However, current funding in this technological pathway is less than $10 million, well behind the funding for biological processing methods.

Separate from direct funding, the DOE has also initiated a loan guarantee program for advanced energy technologies, worth more than $1 billion in 2007. The federal government will back the following six biofuels plants to reduce risk taken on by lenders (DOE 2007c). Table 5-2 summarizes the companies participating in this program. The cover a broad range of technologies and do not give specific preference to ethanol specifically. This program should be continued and expanded.

Alico, Inc.	A first-of-a-kind commercial-scale cellulosic ethanol plant that would use multiple feedstocks and produce multiple products.
Blue Fire Ethanol, Inc.	A commercial-scale cellulosic ethanol plant using an array of low-cost feedstocks.
Choren USA	An industrial-scale biomass gasification facility for clean synthetic diesel fuels in the United States.
Endicott Biofuels, LLC	A second generation biodiesel and bio-derived products plant that would feature a high level of feedstock flexibility allowing for the production of a broad range of biodiesel fuels.
Iogen Biorefinery Partners, LLC	A biorefinery to produce ethanol from a wide range of cellulosic feedstocks and to produce other byproducts of value to several industries.
Voyager Ethanol, LLC	A cellulosic ethanol plant that can accommodate multiple feedstocks in the production of ethanol and higher value byproducts.

Table 5-2: Department of Energy Supported Biofuel Projects

5.2.2 Feedstock Collection and Storage

Policy Definition

For a cellulosic ethanol industry to develop, farmers must be able to collect and store cellulosic feedstocks. This technology must be developed and demonstrated before farmers will be willing to take a large risk on this new industry. This report recommends continued and expanded feedstock collection and storage research and pilot programs.

Background

Cellulosic feedstocks must undergo two stages of transportation. In the first stage, feedstocks are collected from fields; however, current agricultural equipment and practices are not designed to collect crop residues. In the second stage, feedstocks are transported from farms to holding facilities and ethanol processing plants. Unlike corn kernels used in current ethanol production, cellulosic feedstocks require new storage and transportation techniques. In general, cellulosic feedstocks have a lower bulk density than starchy feedstocks like corn kernels or grains of wheat. This decreases the amount of feedstock that can be transported in a given transport volume. Efficient means of transportation and storage must be developed to make cellulosic feedstock harvesting and processing cost competitive and efficient.

Detailed Description

As new feedstocks are developed for dedicated biofuel production, methods of harvesting, collecting, and storing them must also be developed. Potential feedstocks range from grasses like switchgrass to trees like poplar. The harvesting mechanisms will be drastically different than conventional harvesting in many geographic locations.

A major risk for farmers is involved in switching from traditional farm equipment to new and unfamiliar processes. Government support is important to develop the new technologies that will facilitate the growth a new biomass feedstocks. The DOE has taken some initiative in this regard with programs at the Idaho National Engineering and Environmental Laboratory (INEEL) and Oak Ridge National Laboratory (ORNL) (DOE 2007d). Separately the USDA has a number of projects dedicated to the collection and storage of woody biomass. This program runs through the Cooperative State Research, Education, and Extension Service. At this stage, university programs are valuable, but there is a strong need for demonstration projects to deal with logistic issues (USDA 2007e).

5.2.3 Developing and Establishing Sustainable Agriculture Methods

Greater research is needed to establish more sustainable methods of farming, to demonstrate these methods and gain farmers' confidence, and to encourage the adoption of these methods. The following policies are designed to achieve these goals.

5.2.3.1 Direct Education and Agricultural Research

In order to produce energy crops sustainably, farmers will need to switch crops grown and methodology used. To enable this switch, a best-practices model needs to be developed. Developing this model will require research into new crop combinations and methodology. Once developed, this knowledge needs to be communicated to the farmers themselves.

5.2.3.2 Develop Regional Energy Crop Portfolios

Farming is inherently a region specific activity; policies advocating individual crops should strongly be avoided. These policies distort what would otherwise be the profitable and locally appropriate crops. Regional energy crop portfolios *should* be developed, however, and local academic institutions such as extension schools should be involved.

The payoff for energy crops will ultimately be on an energy-per-acre basis. Regional crop portfolios should include simple payoff matrices which highlight the energy yield per acre. These matrices will highlight locally profitable crops and allow farmers to utilize their land most efficiently.

5.2.3.3 Develop Regional Crop Rotations

Monoculture crops grown on the same land year after year damage soil quality, and reduced soil quality requires more fertilizer input. Crop rotations, however, have been shown to keep higher yields (Peel 1998). One of the most established current crop rotations is a corn and soybean rotation. New rotations will need to be developed and proven using on a region by region basis. Proven rotations will provide farmers with the confidence to switch production methods.

5.2.3.4 Develop Experimental and Demonstration Energy Farms

The US government has previously developed experimental farms through various departments and funding to extension schools (USDA no date). There are also small non-government-sponsored farms currently devoted to energy crop research. These farms should be expanded to show possibilities for scale production. Experimental and demonstration farms will serve as a model for best practices and provide more accurate cost data. They will reduce risk for farmers by demonstrating the viability of new crop rotations and expected returns on crops.

5.2.4 Stakeholder Response

Phase 1b is unlikely to encounter a strong resistance; a summary of stakeholder positions regarding the policy initiatives is given below in Figure 5-17. This set of research and development policies would gain support mainly from feedstock producers and ethanol producers as it provides these stakeholders with additional production options. Also, competing feedstock users would also support this policy as new technologies would lower demand for current feedstocks.

Environmental and public health groups would support these policies because they shift towards lower impact production methods. Environmental groups may raise concerns over increased biomass collection, but these should be allayed by funding for sustainable agricultural methods.

Although no strong opposition is expected, the government would have to allocate budget for the R&D spending. It would also have to balance this research with similar R&D demands from other fuel alternatives to ethanol. A full description of expected stakeholder responses can be found in Appendix 4:.

	Final Stakeholder Analysis			
	Phase 1B			
	Policy Objective: Fostering Next Generation Biofuels and Agriculture			
	Stakeholders / Specific Policy Tools:	R&D funding for advanced processing technologies	R&D for biomass Collection	R&D funding for sustainable agricultural methods
1	Agricultural Suppliers	↗	↗	↗
2	Feedstock Producers	↑	↑	↑
3	Competing Feedstock Users	↑	↑	↗
4	Ethanol Producers	↑	↑	↗
5	Petroleum Industry	→	→	↗
6	Non-Traditional Ethanol Substitutes	→	→	→
7	Fuel users	↑	↗	↗
8	Environmental & Public Health Groups	↑	↗	↑
9	Automakers	→	→	→
10	Government	↘	↘	↘

Figure 5-17: Summary of Stakeholder positions regarding Phase 1b

5.3 Phase 2: Market Transition

The goal of this phase is to ready the domestic biofuel market for transition into a liberalized global biofuel market (Phase 3). In order to achieve this market transition, this report proposes three policies. The first is to allow harvesting of perennial grasses from Conservation Reserve Program (CRP) land to give farmers a low risk opportunity to transition into biomass production. The second policy is to develop biofuel production standards for all biofuels entering the U.S. market. The final policy is to change the current tax incentives to greenhouse gas displacement incentives.

5.3.1 Allow Harvesting of Perennial Grasses

Policy Definition

In order to foster the development of a cellulosic ethanol industry, there must be a readily available supply of cellulosic material. Additionally farmers must be able to efficiently collect these feedstocks. A low risk option for farmers to begin collecting and selling cellulosic biomass is to allow farmers with land enrolled in CRP to harvest the grass growing on these lands.

Background
The Conservation Reserve Program (CRP) is the flagship conservation program administered by the United States Department of Agriculture (USDA). The program was authorized by the Food Security Act of 1985 with a national enrollment cap of 45 million acres. The most recent change to the program came in the 2002 Farm Bill which set the national enrollment cap to 39.2 million acres. As of September 30, 2007, there were approximately 36.9 million acres enrolled in the program (USDA 2007b).

Farmers enrolled in the program are required to plant permanent (perennial) vegetation on marginal land in exchange for annual rental payments. The land is enrolled in this program on long term contracts of 10-15 years. Farmers are penalized for violating the contract or tilling the land while it is enrolled in the program.

Detailed Policy Description
Since the harvesting of perennial grasses from CRP land can be achieved without tilling the soil, the primary goal of the program can be achieved even if farmers are allowed to cut the grasses during the year. This report recommends that the USDA create temporary allowances for farmers with land enrolled in CRP to harvest these grasses on the condition that this is done in a no-till, no fertilizer manor. This will allow farmers to develop collection techniques without risking high-yield crop grounds on new energy crops. This program must be temporary to avoid creating another long-term subsidized ethanol industry.

5.3.2 Develop National and International Biofuels Standards

Policy Definition
In the current environment, a multitude of incentives encourage farmers plan for short term yields rather than the long term viability of the land. As discussed in section 4, heavy fertilizer use, irrigation, herbicides, and monocultures increase short term yields and profitably at the cost of land quality and public health. If a farmer were to employ more methods in the current market, he would produce lower yields per acre and be unable to compete profitably. To correct these failures, an international biofuel certification standard should be implemented.

Background
The idea of biofuel certifications has several international precedents. The United Kingdom has already enacted a biofuel standard with sustainability requirements, the Renewable Fuel Transportation Obligation (RFTO). The RFTO requires producers to report on net greenhouse gas impacts and sustainability of fuels produced (Doornbush 2007). Brazil has also enacted a certification program, the Social Fuel Seal; certified fuels earn a higher tax exemption (Doornbush 2007). Switzerland approved an amendment in 2007 which requires an ecological and social impact assessment (Doornbush 2007). In addition the Netherlands and European Commission are considering future requirements for fuel sustainability (Doornbush 2007), and the Roundtable on Sustainable Biofuels is developing a complete sustainability assessment. In addition to biofuel standards, international frameworks for certification and enforcement already exist for organic production.

Biofuel standards need not be limited to foreign countries. Both the U.S. House and Senate have already passed legislation that would require the study of the many disparate effects of increased biofuel production, though these bills have not yet become law. In particular, section 164 of H.R.6, the Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007, passed by Senate on June 21, 2007, would require the study of "air and water quality and the quality of other natural resources… land use patterns… the rate of deforestation in the United States and globally… greenhouse gas emissions… significant geographic areas and habitats with high biodiversity values… the long-term capacity of the United States to produce biomass feedstocks." Section 204 of an alternative version of H.R.6, passed by the House on December 6, 2007 under the name Energy Independence and Security Act, would require the study of "Environmental issues, including air quality, effects on hypoxia, pesticides, sediment, nutrient and pathogen levels in waters, acreage and function of waters, and soil environmental quality… Resource conservation issues, including soil conservation, water availability, and ecosystem health and biodiversity, including impacts on forests, grasslands, and wetlands… [and] the growth and use of cultivated invasive or noxious plants and their impacts on the environment and agriculture."

Detailed Policy Description

Certification of biofuels should be based on a full life cycle analysis. As shown earlier in (Figure 4-6) the impact of biofuel production varies by crop and region. Certifying based on only one portion of the cycle will distort the most effective options and fail to incorporate externalities.

Crafting an effective biofuel standard requires an open long-term outlook. Planting practices change on a 10-40 year time scale. Also, national policies must also be flexible enough to take into account the inherently local nature of crop selection and production methodology. Policies should not favor individual crop species but allow farmers to choose the most effective crops; however, invasive species should be explicitly excluded. Additionally, policies must acknowledge the distributed and variable nature of agriculture production. The fertilizers, herbicides, and water use vary with yearly weather patterns. For example a cap designed to minimize water usage may damage crops in dry years; however, a cap optimized for drought years allows inefficient water use for all other time periods. This variability and the distributed nature of agriculture make a cap based policy difficult to enforce effectively. Considering the current subsidy structure in the US, financial incentives must carefully balance the desires for a self-regulating system, creation of a stable biofuel market and international trade agreements. Additionally, financial incentives should include diminishing rates. This provision should prevent incentive structures from becoming entrenched and allow less farmer reliance on government support. A certification scheme should allow for a broad variety of crops, avoid a cap system, and embed diminishing financial incentives.

It is imperative for environmental quality and local health that the baseline is not determined using monoculture crops. The experimental farms and regional crop rotations discussed in Phase 1b should be used to establish baselines for pesticide, water, and fertilizer use.

Greenhouse gases and ecological destruction are global issues. Simply displacing environmental degradation is not acceptable. One of the most infamous examples of this displacement is the burning of peatland and increased use of fertilizer in Indonesia in order to produce palm oil for biodiesel. Because of the migration to palm oil production, Indonesia is now the third largest highest carbon emitter, only behind the US and China (Rosenthall 2007). Thus, biofuel certification must be applied internationally.

5.3.3 Greenhouse Gas Displacement Incentive

Policy Definition and Precedent

The blender tax credit should be allowed to expire in 2010 and be replaced with lifecycle-based greenhouse gas displacement incentives. These incentives will be fuel neutral and directly address the goal of reducing global warming gases. Lifecycle analysis is the current favored form of emissions evaluation, and lifecycle greenhouse gas evaluation is already required in the United Kingdom's Renewable Transport Fuel Obligation (RTFO). In addition to the United Kingdom's RTFO, the United States Federal Aviation Administration uses lifecycle analysis in cost benefit analysis (Roof et al. 2007).

Background

The current tax credit was designed to build ethanol production; however, it does not address the environmental goals of biofuel production. As shown by Groode, the production method and feedstock greatly impacts the greenhouse reduction levels for ethanol (2007). Cellulosic ethanol, for example, is predicted to have dramatically lower GHG emissions than current corn based ethanol (Groode 2007). The current blender tax credit applies to all ethanol equally, and does not account for these differences.

Detailed Policy Description

The current tax credit program for ethanol production should be restructured and tied to the full fuel-cycle global warming emissions of the fuel. If avoided global warming emissions are valued at $30 per ton of CO_2-equivalent, a value in line with those needed to drive climate-stabilization goals (Stern, 2007), then corn ethanol that delivers a 10 percent reduction in global warming emissions would earn a 5-cent per gallon advantage over gasoline, while corn ethanol that delivers a 20-percent reduction in emissions would earn a 10-cent per gallon advantage. Cellulosic ethanol that delivered a 90 percent reduction would earn a 45-cent-per-gallon price advantage.[5] Ethanol that delivered no global warming benefit would not be eligible for a tax credit, but would still benefit from the market certainty associated with the oil price floor described previously. Such a system would drive the market towards feedstocks and production processes that are less greenhouse gas intensive.

A particular challenge in assessing the global warming emissions of biofuels lies in the determination of emissions and credits attributable to the co-products that are produced concurrently with biofuels. For example, dry milled corn ethanol co-produces DDGS, and many envisioned cellulosic ethanol plants would co-produce electricity. These credits should be accounted for, but a full analysis of co-product credits is beyond the scope of this report.

Additionally, because petroleum-based fuels and biofuels generate global warming emissions at very different parts of their lifecycles, it is rational to use complete fuel-cycle emissions as the basis of any such policy. Also, any policy should account not just for CO_2 emissions but for

[5] This assumes 11.2 kg CO_2-equivalent per gallon of gasoline (MacKenzie 2007)

emissions of other global warming pollutants, such as methane and nitrous oxide, as well. This policy would thus address both combustion emissions and nitrous oxide from farm production.

5.3.4 Stakeholder Response

A summary of stakeholder positions regarding the policy initiatives is given below in Figure 5-18. The set of policies was designed to make compromises between the implications that individual policies have on specific stakeholders. The main supporters of this set of policies would be the environmental and health organization, because this phase addresses many of their key concerns. Environmental organizations would likely oppose harvesting of grasses from CRP land, but making such a policy temporary and limited in scale could mitigate the harm from this specific policy. The automotive industry can also be expected to support these policies, because the policies make biofuels more sustainable, which in turn helps the automakers to avoid criticism of their products.

Agricultural suppliers, feedstock producers, and ethanol producers can be expected to resist the development of biofuel standards, since they would perceive such a policy as threatening to restrict their operations. Additionally, competing feedstock users may resist the development of standards out of a fear that the standards could have a spillover effect into increased food prices. Despite this expected opposition, recent energy bills passed by the House and the Senate have included language calling for the study of the environmental effects of greater biofuel production, a first step toward establishing effective and reasonable standards. A full description of expected stakeholder responses can be found in Appendix 5:.

	Final Stakeholder Analysis		
	Phase 2: Market Transition		
	Policy Objective:		
Stakeholders / Specific Policy Tools:	CO2 displacement incentive (2010)	Allow harvesting of perennial grasses from CRP land	Develop biofuel standards (Total carbon impact, agricultural chemicals, water use, soil quality)
1 Agricultural Suppliers	→	→	↓
2 Feedstock Producers	↗	↑	↓
3 Competing Feedstock Users	↘	→	↓
4 Ethanol Producers	↓	↑	↓
5 Petroleum Industry	→	→	↗
6 Non-Traditional Ethanol Substitutes	↗	→	↑
7 Fuel users	↘	↑	↘
8 Environmental & Public Health Groups	↑	↓	↑
9 Automakers	↑	→	↑
10 Government	↗	↘	↘

Figure 5-18: Summary of Stakeholder positions regarding Phase 2

5.4 Phase 3: Realizing Ultimate Goals for Biofuels Market

The goal of Phase 3 is to create a robust and sustainable international market for biofuels. This would bring the following benefits:

1. **Enhanced energy security.** As discussed in section 4.1, energy security would be improved by diversifying the types of fuels used and the sources that supply them.

2. **Greater market predictability.** A global market for biofuels would lead to greater stability and predictability in prices and demand. More predictable prices would encourage more consumers to use biofuels, which would increase the size of the biofuel market. A larger and more predictable biofuel market would benefit farmers, who would then be able to make long-term planting decisions.
3. **Global Environmental Sustainability.** By implementing sustainability criteria for all biofuels sold in its market, whether domestically or internationally produced, the United States can ensure the protection of its own environment while encouraging best practices throughout the world. Furthermore, such a requirement will protect American farmers from being undercut by unsustainable biofuels produced abroad.

This report recommends the implementation of biofuel standards coupled with the liberalization of biomass agriculture to establish sustainable markets.

5.4.1 Apply Domestic and International Biofuel Production Standards

Policy Definition
This policy would implement the standards developed in Phase 2 in order to ensure both the quality of the biofuels and the environmental burdens associated with their production.

Background
The implementation of production standards would assure the balance between the energy security, economic, and environmental goals of biofuels production. The standards would be developed in Phase 2, and this development is discussed in more detail in section 5.3.2. As explained in that section, biofuel standards have already been implemented in a few foreign markets, and both the U.S. House and Senate have passed legislation requiring the studies on the impacts of greater biofuel production.

Detailed Description
This policy would set comparable production standards for domestic and international ethanol producers, creating a level playing field and addressing the concerns of domestic producers regarding liberalization. The international application of these standards could follow the same form as domestic standards through an international certification board. An example of this type of operation already in use is the organic certifications used for food in Europe and the United States.

By requiring fuels sold in its market to be produced sustainably, the United States has a unique opportunity to encourage agricultural best practices throughout the world. This influence stems from the fact that the U.S. is likely to remain a large buyer on the world market that biofuel and able to induce producers to cooperate with environmental certification in order to sell into the United States.

5.4.2 Liberalize Biofuel Market

Policy Definition
Eliminate the 54¢ per gallon import tariff on biofuel in order to open the U.S. to world markets.

Background
The U.S. trade policy on ethanol includes both an ad valorem tariff of 2.5 percent and an import duty of 54¢ per gallon. This policy was recently extended through January 1, 2009. The principal advocates for maintaining this tariff structure are US domestic farmers, represented by numerous lobbying groups as well as the representatives from the Corn-Belt region. This constituency has a strong interest in maintaining the import tariffs to protect US domestic ethanol industry, mainly from the Brazilian ethanol industry. Brazilian ethanol is produced from sugar cane and the average delivery price is only $1.45 for an equivalent gallon of gasoline as opposed to $1.61 for domestic ethanol (Hausmann, R., 2007, Tokgoz et al. 2007).

According to a recent study, however, evidence does not exist to suggest that the Brazilian ethanol industry has a long-term competitive advantage over U.S. domestic production. Gallagher et al. (2006) instead suggest that there are cyclical periods of advantage for both industries, and that long-term averages show similar profits for both countries if import tariffs are removed.

Detailed Policy Description
Elobeid and Tokgoz (2006) quantified the consequences of tariff elimination between 2006 and 2015. Their simulation showed a decrease of 13.6 percent in U.S. ethanol prices, a 7.2 percent decline in domestic production and a 3.7 percent increase in U.S. ethanol consumption. Accompanying the 7.2 percent domestic decline is a 2.1 reduction in the price of corn. Additionally, ethanol imports rise by 199.04 percent, which pushes the world ethanol prices to increase by 23.9 percent. In this scenario, imports will account for 15.1 percent of the total U.S. ethanol consumption market.

			Tariffs Elimination effect		**Tariffs + Tax credit elimination effect**	
Item	**Units**	**Baseline**	Unit	%	Unit	%
Ethanol Price	US$/gallon	**1.27**	1.57	23.89%	1.48	16,51%
Crude Oil Prices	US$/gallon	**1.39**	1.39	0.00%	1.39	0,00%
Raw Sugar Prices	US$/cwt	**14.34**	14.59	1.77%	14.51	1,22%
Corn Price	US$/bushel	**2.38**	2.34	-1.53%	2.33	-2,10%
DDG Price	US$/ton	**78.47**	79	0.68%	79.2	0,94%
Gluten Feed Price	US$/ton	**58.8**	58.5	-0.50%	58.39	-0,69%
US Ethanol Production	Million Gallons	**7,063**	6,563	-7.23%	6,384	-9,92%
US Ethanol Consumption	Million Gallons	**7,458**	7,730	3.75%	7,310	-2,12%
Net US imports	Million Gallons	**396**	1,169	199.04%	929	136,97%
Net Gasoline Consumption	Million Gallons	**152,796**	152,962	0.11%	152,699	-0,06%
Share of ethanol in Gasoline	Million Gallons	**4.6%**	0.048	3.74%	4.5%	-2,26%
US Ethanol Price	US$/gallon	**1.95**	1.68	-13.57%	1.59	-18,38%

Table 5-3: Summary of effects of ethanol market liberalization

Source: Adapted from Elobeid and Tokgoz (2006)

In addition, the decrease of corn demand has an effect on corn byproducts like dried distillers grains (DDGS) and gluten feed (Gluten meal and corn oil) which are also used in livestock and poultry feeds. DDG's have a marginal price increase 0.94 percent, and gluten feed a price reduction of -0.69 percent. Hence the elimination of trade barriers doesn't impose an additional food versus fuel problem with the food industry stakeholders. A diversified energy portfolio also reduces the volatility effects of shock prices in oil, which benefits the American economy as discussed in section 4.

5.4.3 Stakeholder Response

A summary of stakeholder positions regarding the policy initiatives is given below in Figure 5 8. The final phase of policy strategy is dependent on the successful implementation of the previous phases. It is therefore possible that stakeholders adapt in the time before these policies are enacted. Despite this uncertainty it is generally expected that the enforcement of environmental standards will not be initially received well by farmers. However, environmental farm standards will ideally be generated from research in advanced harvesting techniques as well as environmental impact. The main supporters of this set of policies would be the environmental and health organizations. Additional support is expected from fuel users as opening borders to biofuel trade will likely increase the amount of available biofuels and therefore drop the cost.

		Final Stakeholder Analysis	
		Phase 3:	
		Policy Objective: Create a World Market for Biofuels	
	Stakeholders / Specific Policy Tools:	Implement biofuel standards (Total carbon impact, agricultural chemicals, water use, soil quality)	Liberalize biofuel market
1	Agricultural Suppliers	↓	→
2	Feedstock Producers	↓	↘
3	Competing Feedstock Users	↓	↑
4	Ethanol Producers	↘	↓
5	Petroleum Industry	↗	→
6	Non-Traditional Ethanol Substitutes	↑	↓
7	Fuel users	→	↑
8	Environmental & Public Health Groups	↑	→
9	Automakers	↑	↘
10	Government	→	→

Figure 5-19: Summary of Stakeholder positions regarding Phase 3

Strong opposition is expected from stakeholders in the biofuel value chain (feedstock suppliers, feedstock producers and ethanol blenders), but the standards implementation would assure them that international competitors would have to comply with the same set of production rules. This is a crucial policy when considering the environmental tradeoffs in biofuel development. Domestic biofuel feedstock agriculture has the potential to lead by example, by restricting access to one of the largest liquid fuel markets in the world. A full description of expected stakeholder responses can be found in Appendix 5.

6 Conclusions

Biofuel production in the United States is driven by the potential to reduce global greenhouse gas emissions, promote rural economic development, and increase energy security. Achieving these goals is problematic due to a series of trade-offs among economic growth, energy security, climate change, food prices, public health, and environmental impacts. Current U.S. biofuel production is more than 95 percent corn ethanol (Worldwatch 2006) and does not adequately address these trade-offs, focusing solely on maximizing agricultural yields.

This report recommends a comprehensive set of policies to mitigate the trade-offs described above and establish a framework for the growth of a sustainable biofuel market. The policy portfolio contains three phases, each of which includes two to four specific policy proposals. It is essential to note that the individual policies will not stand alone, because each successive phase relies on the successful implementation of prior policies. Many of the recommended policies have been proposed or deployed already in the United States or elsewhere.

Phase 1a

The goal of Phase 1a is to remove risk from the biofuels market to encourage investment and growth. The specific policies recommended include a fuel price backstop, new incentives for flex-fuel vehicles, and infrastructure development incentives.

Phase 1b

The goal of Phase 1b is to continue and expand current research and development activities in the areas of advanced processing, biomass collection, and sustainable agricultural practices. Phase 1b establishes the framework to address the climate change, public health, and environmental impacts of biofuel production.

Phase 2

The goal of Phase 2 is to begin transitioning the market to advanced biofuels. This is accomplished by replacing the blender tax credit with a variable greenhouse gas displacement incentive, allowing narrow harvesting of grasses on Conservation Reserve Program (CRP) land, and capitalizing on Phase 1 research in order to develop sustainable biofuel standards. Phase 2 continues to address climate change, public health, and environmental impacts. The greenhouse gas displacement incentive and the harvesting of CRP grasses also begin to address the food versus fuel trade-off by favoring cellulosic biomass and other non-food feedstocks.

Phase 3

Finally, the goal of Phase 3 is to enact policies to sustain a long-term biofuels market. Specifically, Phase 3 implements the sustainable biofuel standards developed during Phases 1 and 2 and liberalizes the biofuel markets through tariff removal. This final phase addresses the climate change, public health, and environmental impacts through the sustainable biofuel standards and enhances energy security through diversification of sources.

Stakeholder Responses

The policy package proposed will likely encounter initial opposition from both agriculture and the petroleum industries. The agriculture industry will respond most strongly to the biofuel standards; however, agricultural opposition should be tempered by biofuel growth policies and the increased research and development funds. Diversified fuel companies – those that sell multiple fuels including biofuels – will fight initial policies but may embrace the biofuel sector as it becomes more profitable. Dedicated petroleum companies, for example those who work in upstream production, are unlikely to support any biofuel policies. The way to counteract this pressure is by building a strong constituency for biofuels. Therefore, the success of this three-phase strategy depends upon the correct implementation of each sequential stage.

7 Appendices

Appendix 1: Policy Affecting Ethanol Production

Specific Policy	**Stakeholders**	**Encapsulating Policy**	**Regulation**	**Other**
Renewable Fuel Standard (RFS)[6]	Transportation end-use	2005, Energy Policy Act	Use 4 billion gallons of biofuel by 2006, 7.5 billion gallons of biofuel by 2012	Also employs credit multipliers. See Table 7-4 for information
Small Producer Tax Credit	Ethanol producers	2005, Energy Policy Act	$0.10 per gallon tax credit for small biodiesel and ethanol producers (less than 30 million gallons per year)	production limit for ethanol producers was moved to 60 million gallons per year through 2008
Alternative Fuel Infrastructure Tax Credit	Ethanol Producers	2005, Energy Policy Act	Provides a tax credit equal to 30% of the cost alternative refueling property, up to $30,000 for business property. Qualifying alternative fuels are natural gas, propane, hydrogen, E85, or biodiesel blends of B20 or more. Buyers of residential refueling equipment can receive a tax credit for $1,000[7].	
Federal Fleet Dual-Fuel Vehicles: Fuel Use Requirement		2005, Energy Policy Act	Requires federal fleets to use alternative fuels in dual-fuel vehicles unless the Secretary of Energy determines an agency qualifies for a waiver. Grounds for a waiver are: alternative fuel is not reasonably available to the fleet and the cost of	

[6] Tyner, 2007
[7] http://www.eere.energy.gov/afdc/incentives_laws_epact.html

			alternative fuel is unreasonably more expensive that convention fuel[8].	
Blender Tax Credit	Ethanol producers	2004, Jobs Creation Act	$0.51 per gallon tax credit for blenders (those who mix ethanol with gasoline)	Also extended the ethanol tax exemption to 2010
Direct Payments for commodity crops	Feedstock producers	2002, Farm Bill	Price supports paid to farmers to grow commodity crops	Payments for cereal crops, corn, rice, soybeans and oil seeds.
Counter-cyclical payments for commodity crops[9]	Feedstock producers	2002, Farm Bill	Creates an effective price floor for commodity crops	Payments for cereal crops, corn, rice, soybeans and oil seeds.
Conservation Reserve Program (CRP)[10]	Feedstock producers	1985, Food Security Act	Annual payments to farmers for 10-15 year contracts to establish grass, shrub and tree cover on marginal lands	Currently 36 million acres enrolled with a cap of 39.2 million acres
Conservation Reserve Enhancement Program (CREP)[11]	Feedstock producers	1985, Food Security Act	Similar to CRP, but a project based program to address localized environmental issues	Employed in partnership with local and tribal governments
Wetlands Reserve Program[12]	Feedstock producers, land owners	1990, Farm Bill	Cost sharing program for landowners to restore wetlands	More than 1.9 million acres enrolled

[8] Ibid.
[9] USDA, 2007
[10] Ibid.
[11] Ibid.
[12] Ibid.

<table>
<tr><td>Fuel</td><td>Equivalence Value</td><td rowspan="6">Equivalence value is the ratio of the volume credited for the RFS compliance to the actual volume of fuel used. For example, 1 gallon of biodiesel counts as 1.5 gallons toward the RFS obligation.</td></tr>
<tr><td>Corn ethanol</td><td>1.0</td></tr>
<tr><td>Biobutanol</td><td>1.3</td></tr>
<tr><td>Biodiesel (FAME)</td><td>1.5</td></tr>
<tr><td>Non-FAME renewable diesel</td><td>1.7</td></tr>
<tr><td>Cellulosic & waste-derived ethanol</td><td>2.5</td></tr>
</table>

Table 7-4:Equivalence values for various renewable fuels

History of Ethanol Subsidy Legislation (*Source: (Commerce, 2006) North Dakota Chamber of Commerce)*

1978 Energy Tax Act of 1978

$0.40 per gallon of ethanol tax exemption on the $0.04 gasoline excise tax

1980 Crude Oil Windfall Profit Tax Act and the Energy Security Act:

Promoted energy conservation and domestic fuel development

1982 Surface Transportation Assistance Act

Increased tax exemption to $0.50 per gallon of ethanol and increased the gasoline excise tax to $0.09 per gallon

1984 Tax Reform Act

Increased tax exemption to $0.06 per gallon

1988 Alternative Motor Fuels Act

Created research and development programs and provided fuel economy credits to automakers

1990 Omnibus Budget Reconciliation Act

Ethanol tax incentive extended to 2000 but decreased to $0.54 per gallon of ethanol

1990 Clean Air Act amendments

Acknowledged contribution of motor fuels to air pollution

1992 Energy Policy Act

Tax deductions allowed on vehicles that could run on E85

1998 Transportation Efficiency Act of the 21st Century

Ethanol subsidies extended through 2007 but reduced to $0.51 per gallon of ethanol by 2005

2004 Jobs Creation Act

Changed the mechanism of the ethanol subsidy to a blender tax credit instead of the previous excise tax exemption. Also extended the ethanol tax exemption to 2010.

Appendix 2: Economic Evaluation of Biofuel Production

A generic production economics model can be applied to ethanol production:

$$C_{EtOH} = C_{Feedstock} / Y_{EtOH} + ACC + OC - \square Y_{Co\text{-}product} \text{ x } P_{Co\text{-}product})$$

Where C_{EtOH} is cost of final ethanol product, $C_{Feedstock}$ is the cost of feedstock, Y_{EtOH} is the yield of ethanol per unit of feedstock, ACC is the annualized capital cost per unit of production, OC is the operating cost per unit of production, $Y_{Co\text{-}product}$ is the yield of each co-product per unit of ethanol production, and $P_{Co\text{-}product}$ is the price of the co-product.

The feedstock cost depends on the costs of farming, transporting, and storing the particular feedstock. Low-intensity crops are cheaper to farm, and dense crops are cheaper to transport and store. Ethanol yield depends on feedstock characteristics and the processing technology used; feedstocks with large amounts of easily-extractable sugar/starch/cellulose will deliver the highest yields. Capital and operating costs increase with process complexity, since the additional steps require more equipment and more advanced enzymes. A key design tradeoff exists between the economies of scale realized within a large plant and the lower transportation costs associated with a smaller plant. Co-products such as electricity or distillers dried grains with solubles often play an important role in determining the overall process economics.

The production economics model largely determines how crops will be valued by ethanol producers. While specific crop suitability will vary by region, the ideal crops from a producer's point of view will all exhibit certain characteristics:

1. High ratio of fermentable material to mass.
2. High ratio of fermentable material to volume.
3. High yield of fermentable material per acre farmed.
4. Easy extraction of fermentable material.

The first three properties are important for reducing feedstock storage and transport costs. The third property is also important from a policy perspective, for maximizing the amount of fuel that can be produced from a given land area, while the fourth property is key to reducing processing costs. A major challenge in selecting an energy crop is choosing a crop that balances these criteria appropriately. There is ongoing research into the development of alternative feedstocks and production methods to address these issues.

Appendix 3: Phase 1a Stakeholder Reaction Matrix Source

	Final Stakeholder Analysis			
	Phase 1A			
	Policy Objective: Building a Stable Biofuels Market			
	Stakeholders / Specific Policy Tools:	Fuel Price Backstop	Incentieves for flex fuel vehicles	Infrastructure development incentives
1	Agricultural Suppliers	↑	↑	↑
2	Feedstock Producers	↑	↑	↑
3	Competing Feedstock Users	↘	↓	↓
4	Ethanol Producers	↑	↑	↑
5	Petroleum Industry	↓	↘	↘
6	Non-Traditional Ethanol Substitutes	↗	↓	↘
7	Fuel users	↘	↑	↑
8	Environmental & Public Health Groups	↑	↑	↗
9	Automakers	↗	↘	→
10	Government	↗	↘	↘

Table 7-5: Detailed analysis of Phase 1a stakeholder positions

Phase 1a Stakeholder Analysis			
Stakeholder	**Position on Floor Tax on Petroleum**	**Position on Incentives to Flex Fuel Vehicles**	**Position on Infrastructure Development Incentives**
1. Agricultural Suppliers	Would support a tax on petroleum as this means that new investors would enter the biofuel market	Would support incentives to flex fuel vehicles as this increases the size of the potential market for biofuels	Would support infrastructure development as this increases the outreach of biofuels, which as a consequence increases the demand for their agricultural supplies.
2. Feedstock Producers	Would support a tax on petroleum as this helps to keep biofuels competitive against gasoline prices	Would support incentives to flex fuel vehicles as this increases the size of the potential market for biofuels.	Would support this policy as this increases the potential demand for biofuels. Which increases the market for their agricultural products
3. Competing Feedstock Users	Do not have a strong commitment to oppose to this policy because it does not increase the amount of biofuels already being produced	Would oppose incentives to flex fuel vehicles as this could create a higher demand for biofuels, raising their production prices.	Would oppose to this policy since this would expand the potential demand for biofuels. As a consequence, the required feedstock would also have an increase in demand
4. Ethanol Producers	Would support a tax on petroleum as this helps to keep biofuels competitive against gasoline prices	Key stakeholder. They would benefit because their potential market would raise due to both an increase in the amount of flex fuel vehicles, and also an	Key stakeholder. Would support this policy since this increases the potential market for their product

		increase in the percentage of ethanol their engines could use	
5. Petroleum Industry	Key stakeholder. Would not support a tax that it is aimed to support ethanol at a competitive price against gasoline.	Would not support a push for flex fuel vehicles since this could have the potential to take some of their market. As the percentage of fuel blended is still low, this only presents a distant threat.	Would not support this policy as this new infrastructure has the potential to take some of their market. As the amount of ethanol being blended in gasoline is still low, this only represent a distant threat
6. Non-Traditional Ethanol Substitutes	Would support floor tax on petroleum as this also helps their fuel substitutes and additives to become cost effective.	Would not favor specific policies that favor ethanol. They want their technologies to succeed so they would push for similar policies in their direction	Would not support incentives for specific infrastructure development since this only favors ethanol.
7. Fuel users	Key stakeholder. Would not support a tax that could have the potential to increase the prices of gasoline (if oil price is low)	Key stakeholder. They would support flex fuel vehicle incentives as they could get their vehicles cheaper.	Key stakeholder. They would support this policy as this would mean more availability of ethanol at service stations. If ethanol is price competitive against gasoline, they benefit from cheaper fuel.
8. Environmental & Public Health Groups	Environmental groups would favor tax floors on petroleum as this helps other clean energy to be cost competitive.	Environmental groups would favor flex fuel vehicles if they use environmentally sound biofuels. Public Health groups would favor this policy since these types of vehicles have lower emissions of particulate material than regular gasoline engines.	This group would favor an expansion on the infrastructure for biofuels. They have concerns about the pollution that ethanol runoffs might have on the environment.
9. Automakers	Would support a tax on petroleum as this moves the pressure from CAFE standards. This could also benefit their alternative technologies to be cost competitive against gasoline.	Mildly against, weaker incentives will be less profitable than current incentive, but profitable nonetheless.	Would not support this policy since this does not necessarily favor their technologies.
10. Government	The Government would benefit from the additional incomes of this tax, but this is policy is hard to sell to the public.	Governments would have to spend resources in the incentives for flex fuel owners.	Governments would have to spend resources in the incentives for infrastructure development.

Appendix 4: Phase 1b Stakeholder Reaction Matrix Source

		Final Stakeholder Analysis		
		Phase 1B		
		Policy Objective: Fostering Next Generation Biofuels and Agriculture		
	Stakeholders / Specific Policy Tools:	R&D funding for advanced processing technologies	R&D for biomass Collection	R&D funding for sustainable agricultural methods
1	Agricultural Suppliers	↗	↗	↗
2	Feedstock Producers	↑	↑	↑
3	Competing Feedstock Users	↑	↑	↗
4	Ethanol Producers	↑	↑	↗
5	Petroleum Industry	→	→	↗
6	Non-Traditional Ethanol Substitutes	→	→	→
7	Fuel users	↑	↗	↗
8	Environmental & Public Health Groups	↑	↗	↑
9	Automakers	→	→	→
10	Government	↘	↘	↘

Table 7-6: Detailed analysis of Phase 1b stakeholder positions

Phase 1b Stakeholder Analysis			
Stakeholder	**Position on R&D funding for advanced processing technologies**	**R&D for Biomass Collection**	**Position on R&D funding for sustainable agricultural methods**
1. Agricultural Suppliers	This group would support this policy since it might open a bigger market for their agricultural supplies	This group would not be against this policy since it might open a bigger market for their agricultural supplies	Would support this policy since crop rotation would open new possibilities for their agricultural products
2. Feedstock Producers	Would support this policy since this might provide them insights on more convenient crops to produce.	Would support this policy since this might provide them additional incomes from the agricultural residues they are leaving on the field.	Would support this policy since it might provide them techniques for achieving higher yields.
3. Competing Feedstock Users	Would support this policy as these new technologies would take some pressure off the current feedstocks being used.	Would support this policy as these new technologies would take some pressure off the current feedstocks being used.	Would support this policy since this new methods might increase the yield of current crops easing pressure on current feedstocks
4. Ethanol Producers	Would support this policy since this might provide additional sources of feedstock. A bigger supply source would increment the supply, dropping their production prices.	Would support this policy since a bigger supply of biomass would make cellulosic processing cheaper.	Would support this policy since it might deliver better production methods for their suppliers (feedstock producers)
5. Petroleum Industry	They would not find a serious threat for their industry in this policy.	They would not find a serious threat for their industry in this policy.	They would not find a serious threat for their industry in this policy.

6. Non-Traditional Ethanol Substitutes	Would not favor this policy since it is only applicable to biofuels. For example fuel cell manufacturers would push for the same kind of R&D spent on their technologies.	Would not favor this policy since it is only applicable to biofuels. For example fuel cell manufacturers would push for the same kind of R&D spent on their technologies.	Would not favor this policy since this targets only agricultural alternative fuels. Would push for the same kind of R&D spending for their technologies.
7. Fuel users	Would favor this policy since it might provide additional sources of biofuels, incrementing the supply of them.	Would favor this policy since it might produce cheaper biofuels.	Would favor this policy since it might produce higher yields of feedstock that would produce a bigger supply of ethanol
8. Environmental & Public Health Groups	Would favor this policy since it might produce more environmentally sound biofuels.	Would favor this policy since cellulosic ethanol is more environmentally sound than current ethanol productions. Might raise concerns about the amount of nutrients that are displaced from the land.	Would favor this policy since sustainable agricultural methods would mitigate the current effect of ethanol on the environment.
9. Automakers	Would demand that the same amount of money to be spent in their technology	Would demand the same amount of money to be spent in their technology.	Would not make a strong case to oppose to this policy
10. Government	Would have to allocate budget for this policy	Would have to allocate budget for this policy	Would have to allocate budget for this policy

Appendix 5: Phase 2 Stakeholder Reaction Matrix Source

Final Stakeholder Analysis

Phase 2: Market Transition

Policy Objective:

	Stakeholders / **Specific Policy Tools:**	CO2 displacement incentive (2010)	Allow harvesting of perennial grasses from CRP land	Develop biofuel standards (Total carbon impact, agricultural chemicals, water use, soil quality)
1	Agricultural Suppliers	→	→	↓
2	Feedstock Producers	↗	↑	↓
3	Competing Feedstock Users	↘	→	↓
4	Ethanol Producers	↓	↑	↓
5	Petroleum Industry	→	→	↗
6	Non-Traditional Ethanol Substitutes	↗	→	↑
7	Fuel users	↘	↑	↘
8	Environmental & Public Health Groups	↑	↓	↑
9	Automakers	↑	→	↑
10	Government	↗	↘	↘

Table 7-7: Detailed analysis of Phase 2 stakeholder positions

Phase 2 Stakeholder Analysis			
Stakeholder	**Position on C02**	**Position on**	**Position on Development**

	Displacement Incentives	Allowing harvesting of perennial grasses	of Biofuel Standards (Total Carbon Impact, Agricultural Chemicals, Water Use, Soil Quality)
1. Agricultural Suppliers	Removing current tax credits reduces in 2.54% the domestic ethanol production (Elobeid and Tokgoz, 2006). Changing it to CO2 Removal tax incentive could open new opportunities for engineering dedicated CO2 removing feedstock.	Would not oppose to this policy, but would not find a direct benefit for their products.	Would not support this policy since it relies on reducing the amount of fertilizers used in agriculture, which is part of their main business.
2. Feedstock Producers	Removing current tax credits reduces corn prices in 0.42% and reduces sugar prices in 0.56%. Changing it to a CO2 removal tax incentive would change their current production practices, affecting their crops in the short run. In the long term they could benefit from switching to crops that are more efficient in removing CO2	Would support this policy since it might give them an additional income source.	Would not support this policy since it might reduce their yields in the short run.
3. Competing Feedstock Users	Removing current tax credits would affect the feedstock and byproducts prices at a marginal rate. (DDG increases in 0.25% and gluten feed reduces in 0.19%, Elobeid and Tokgoz, 2006). This group would not have a strong case to oppose these measures but would not favor them either.	Would support this policy since perennial grasses are not used as feedstock for this stakeholder.	Would not support this policy since a reduced yield would result in a lower supply, raising the prices of the feedstock they use.
4. Ethanol Producers	Key stakeholder. Would not favor the phase out of the current tax credit changing it to an CO2 displacement incentive	They would favor this policy since it might provide them an additional feedstock source for ethanol production.	Would not support this policy since this might reduce their feedstock supply. A reduced supply increases their production costs.
5. Petroleum Industry	The oil industry would not oppose a change in the tax credits since the share of ethanol in gasoline consumption would be maintained if not declined	Would not oppose to this policy, but would not find any benefit in it for their industry	Would support this policy since it reduces the supply of ethanol. As the current ethanol volume is still small it does not present a threat for this industry
6. Non-Traditional Ethanol Substitutes	Ethanol substitutes would support tax credits change since their alternative products could become more cost competitive against ethanol	Would not oppose to this policy, but would not find any benefit in it for their industry	Would support this policy since it might reduce the amount of ethanol being produced. This would allow their technologies to be more cost competitive.
7. Fuel users	This group would not favor a tax credit change since this might increase the total cost of biofuels due to technology adoption costs	Would support this policy since it provides a higher supply of feedstock for ethanol production	Would not support this policy since it might increase the cost of ethanol as a result of a reduction in supply due to the production standards
8. Environmental	Environmental groups would	Would not favor this	Key Stakeholder. Would

& Public Health Groups	support this change as a measure to mitigate green house gases.	policy since it might destroy natural habitats	support this policy since it would lower the environmental consequences and health hazards that biofuels impose in the population.
9. Automakers	Tax credits change could produce a reduction in the domestic ethanol consumption. Lower consumption diminishes pressures over ethanol and alternative technologies gain support.	Would not oppose to this policy, but would not find any benefit in it for their industry	Would support this policy since it would transfer some of the environmental responsibility to the fuel makers.
10. Government	Governments would support tax credit change since this eases woes on food problems.	Would have to increase the surveillance to enforce that no perennial grasses are removed; only harvested. This would require an additional enforcement task	They would accept this policy since higher biofuel standards would reduce health risks for the population. Nevertheless, it is going to be difficult to convince the agricultural constituency.

Appendix 6: Phase 3 Stakeholder Reaction Matrix Source

		Final Stakeholder Analysis	
		Phase 3:	
		Policy Objective: Create a World Market for Biofuels	
	Stakeholders / Specific Policy Tools:	Implement biofuel standards (Total carbon impact, agricultural chemicals, water use, soil quality)	Liberalize biofuel market
1	Agricultural Suppliers	↓	→
2	Feedstock Producers	↓	↘
3	Competing Feedstock Users	↓	↑
4	Ethanol Producers	↘	↓
5	Petroleum Industry	↗	→
6	Non-Traditional Ethanol Substitutes	↑	↓
7	Fuel users	→	↑
8	Environmental & Public Health Groups	↑	→
9	Automakers	↑	↘
10	Government	→	→

Table 7-8: Phase 3 Stakeholder Reaction Detail

Phase 3 Stakeholder Analysis		
Stakeholder	**Position on Biofuel Production Standards Implementation**	**Position on Agriculture Liberalization (Tariffs +Tax credit removal)** (Data source: Elobeid and Tokgoz, 2006)

1. Agricultural Suppliers	They would not support Fuel standards that impose environmental restrictions on the use of fertilizers	Would not favor liberalization because this produces a 9.9% reduction of domestic ethanol production, which comes mainly from corn. But also they might benefit from it as they are multinationals that could get benefits from larger markets
2. Feedstock Producers	Would not support fuel standards that affect their yield and current production methods. Would endorse them only if agriculture liberalization were inevitable	Would not favor liberalization, but as the overall effect on corn prices is a 2.1 percent decline, they cannot make a strong case to oppose to cheaper ethanol. They benefit from the stability in the market.
3. Competing Feedstock Users	Would not support standards that implicate a reduction in the supply of feedstock (like reduction in yield) as this increases the prices of feedstock	The overall effect on feedstock prices and byproducts is marginal (DDG increases in 0.94% and gluten feed reduces in 0.69%). May find an additional benefit from price stability.
4. Ethanol Producers	Would endorse fuel standards only if agriculture liberalization were inevitable.	Key stakeholder. They will oppose modifications on tariffs. Need to compensate in order to gain their support.
5. Petroleum Industry	Would push for biofuel production standards since this reduces the amount of biofuels being produced, reducing its potential threat.	The oil industry would be marginally affected by liberalization. The share of ethanol in gasoline consumption would decline by 2.26%, so they would not oppose this measures.
6. Non-Traditional Ethanol Substitutes	Key stakeholder. Would push for biofuel production standards since this might increase the prices of ethanol, making their technologies more cost efficient.	Ethanol substitutes would not support liberalization. If the price of ethanol drops, their cost would have to be even more cost competitive to gain market share over ethanol.
7. Fuel users	Would not support biofuel standards that might affect the price of ethanol, but would accept them in case this favors trade liberalization since the overall impact in price reduction is positive	This group is also a key stakeholder. They benefit the most from cheap ethanol. They are the only ones with enough stakes to oppose to the ethanol producers lobby.
8. Environmental & Public Health Groups	Environmental groups are key stakeholders in promoting environmental friendly production practices.	Environmental groups would push for environmental standards for imported ethanol
9. Automakers	Would push for biofuel production standards as a way to increase their technologies advantages over biofuels (example, hydrogen does not require fertilizers)	Ethanol substitutes would not support liberalization. If the price of ethanol drops, their cost would have to be even more cost competitive to gain market share over ethanol.
10. Government	Biofuel production standards require an additional effort of enforcement. The implementation of these standards would allow government to have a control over the imported ethanol (in case of trade liberalization).	The government can change its role working as an arbiter between Ethanol producers and Ethanol consumers. Trade liberalization would allow WTO trade compliances.

8 Author Biographies

Ms. Pearl E. Donohoo, Massachusetts Institute of Technology
Ms. Donohoo is a first year Masters student in the Technology and Policy Program. She holds a B.S. in Mechanical Engineering from the Franklin W. Olin College of Engineering. Her current research focuses on the transition of airports to alternative fuels. She has also completed research internships at the National Renewable Energy Laboratory and National Wind Technology Center.

Mr. Donald W. MacKenzie, Massachusetts Institute of Technology
Mr. MacKenzie is a Masters student in the Technology & Policy Program and the Sloan Automotive Laboratory at MIT. Prior to coming to MIT, Mr. MacKenzie spent three years as vehicles engineer and senior analyst in the clean vehicles program at the Union of Concerned Scientists in Washington, DC. There, he developed, analyzed, and advocated for policies to reduce petroleum use and emissions from the transportation sector. He was previously a research engineer for a catalysis research company in Vancouver, Canada, focusing on catalysts for thermochemical ethanol synthesis. He holds a Bachelor of Applied Science degree in chemical engineering from the University of British Columbia.

Mr. Jeffrey L. McAulay, Massachusetts Institute of Technology
Mr. McAulay is a first year student in the Technology and Policy Program. He graduated with a B.S. in Biomedical Engineering from Boston University where he studied microbial bioenergy systems. He went on to work at Nuvera Fuels cells in the automotive fuel reforming group where he contributed to studies on hydrogen contaminant mitigation and product lifetime assessment. He is currently working as a research assistant in the Sloan Automotive Lab.

Mr. Julio Pertuzé, Massachusetts Institute of Technology
Mr. Pertuzé is a first year Masters student in the Technology and Policy Program. He holds an Industrial Engineering degree from the Catholic University of Chile, and an academic diploma in Information Technologies from that same institution. After graduating he worked in the Education and Health Corporation of Las Condes, Chile, where he introduced technology into the municipal school system as well as into local outpatient clinics. His current research is on analyzing best practices towards technology transfer between university and industry.

Mr. Addison Killean Stark, Massachusetts Institute of Technology
Mr. Stark is a graduate student in the Technology and Policy Program at MIT and a graduate research assistant in the Laboratory for Energy and the Environment at MIT. He graduated from the University of Iowa in 2007 with bachelor's degrees in mathematics and chemistry. While at the University of Iowa, he spent 3 years as a research assistant in the University of Iowa Fuel Cell Lab under Dr. Johna Leddy. While at the University of Iowa, he was elected Vice President of the Student Body from April 2006 to April 2007.

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