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Rationalizing the Regulatory Environment for Renewable Energy: Overcoming Constraints to Rapid Growth in the Biofuels Industry

Prepared for the United States Department of Agriculture

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Rationalizing the Regulatory Environment for Renewable Energy: Overcoming Constraints to Rapid Growth in the Biofuels Industry

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Rural Development

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EXECUTIVE SUMMARY

The U.S. Department of Agriculture has tasked Booz Allen Hamilton to investigate an aggressive biofuels policy which would result in industry production of 60 billion gallons per year (BGY) of biofuels by 2025. This amount of biofuels would have the potential to meet up to 17% of the projected 250 BGY transportation fuel demand for 2025, on an energy equivalent basis. The 60 BGY target represents what policymakers currently believe to be the most aggressive yet achievable goal for biofuel production (i.e., ethanol and to a much lesser extent biodiesel) in the U.S. The goal is attainable, but will require significant technological, logistical and socio-economic changes to the current system.

Within the next five years, the ethanol industry will likely reach a tipping point in its transition from a 15 BGY blending component (E10) to an E85 fuel. Significant recent investment in the biofuels sector has driven rapid industry expansion resulting in the likelihood of the U.S. surpassing the 2012 RFS biofuels production target of 7.5 BGY by the end of 2007. This investment interest should continue and support rapid development and commercialization of new conversion technologies. As the footprint of E85 increases and annual biofuels industry production progresses towards 60 BGY, constraints will arise in all four top level elements of the biofuels value chain (feedstock, conversion, transportation and end use).

Forward thinking is essential to coordinate simultaneous expansion throughout the biofuels value chain and avert constraints which could significantly impact the industry's capability for expansion. This paper suggests actions that USDA and the federal government can take to identify these constraints, convene critical stakeholders to discuss solutions and drive consensus of public and private solutions to these issues.

*The significant **feedstock** constraints are:*

- Land and water use for feedstock production sufficient to supply 60 BGY biofuels market is not well understood
- Severe drought and low crop yields could have significant impact on the feedstock availability for conversion to biofuels
- Current re-enrollment of CRP land is high and there is no incentive for land reintroduction for growing dedicated energy crops

*The recommended action to address these **feedstock** constraints is:*

- Create a mechanism to determine what future agricultural practices must be present in 2025 to support a 60 BGY biofuels market and still meet food and feed requirements. This study should examine:
    - The balance between existing agriculture and introduction of new energy crops
    - The pace of land introduction and/or conversion needed to meet future biofuels production targets
    - The potential of introducing drought and pest tolerant and high yield seed hybrids
    - The potential benefits of creating a 'strategic crop reserve' as a hedge against low crop yields
    - How subsidies could impact the production of new feedstocks/dedicated energy crops

- How improved feedstock densification processes can lower costs and risks of biofuels facilities

*The significant **conversion** constraints are:*

- Environmental challenges of conversion technologies affect potential plant siting opportunities
- Economics of new bioconversion technologies are highly dependent on volatile feedstock and biofuels prices
- Limited E85 availability will slow consumer acceptance and use
- Biodiesel production is well below installed capacity

*The recommended actions to address these **conversion** constraints include:*

- Work with states to determine how emerging carbon trading programs, water rights issues and air permitting requirements could potentially impact biofuels industry development
    - Determining what possible coordinated actions can be taken to minimize these impacts
- Create a biofuels security subsidy with a price floor on oil and a price ceiling for feedstock outside of which government support would be triggered to maintain positive economics within the biofuels industry
- Create additional Renewable Fuels Standards specifically for E85 and biodiesel to increase both nationwide availability and demand of E85 and biodiesel

*The significant **transport** constraints are:*

- The existing biofuels transport infrastructure is incapable of supporting 60 BGY of biofuels
- Rail tank-car construction is back-logged 18 months and rail spur lines are becoming overburdened with current shipments of freight and fuel
- No determination has been made as to the feasibility of converting existing petroleum pipelines to accommodate biofuels
- There is a long permitting process required for construction of new pipelines

*The recommended actions to address these **transport** constraints include:*

- Determine the government's role to ensure adequate biofuels transportation capacity
    - Determining when the current biofuels transport infrastructure will be pushed beyond its capacity to accommodate additional volume
    - Examining opportunities to modify existing pipelines or use existing right of ways to transport biofuels
    - Funding research on reducing siting and construction constraints to enable infrastructure development necessary to support rapid industry expansion
- Conduct analysis on the "least cost" strategy for handling the transition to a 60 BGY future
    - Should it be geographically focused or nationally based?
    - What is USDA's role to help shape this future?

The significant ***end use*** *constraints are:*

- As ethanol production moves beyond 15 BGY, a significant increase in consumer demand for E85 will be required to support increased ethanol production
- Current E85 and biodiesel retail availability is limited
- Current production and sale of FFVs is limited
- Additional outlets for ethanol are not established to accommodate an imbalance where supply exceeds national fuel demand

The recommended actions to address these ***end use*** *constraints include:*

- Sponsor public education programs to increase consumer demand for biofuels and FFVs
- Create a national corridor of biofuels refueling stations to increase availability and encourage purchase of both E85 and biodiesel
- Work closely with auto manufacturers to establish incentives to increase production of FFVs
- Develop an export market for U.S. ethanol to support continued ethanol industry expansion through a possible slow transition to E85

Failing to address the most critical issues associated with expansion of the biofuels industry will likely lead to bottlenecks which significantly constrain continued rapid industry expansion and limit its ultimate potential to provide energy security, lessen America's dependence on foreign oil and significantly improve the economic well-being of rural America.

Addressing and resolving these constraints will require considerable coordination and discussion with states and industry to determine the benefits and risks of various government intervention models. While the range of issues and stakeholders is large, the timeframe for ethanol's transition beyond 15 BGY provides an opportunity for well reasoned and robust debate on the issues and for delineation of public and private responses to address these issues. However, the time to begin is now.

USDA should conduct a critical stakeholder meeting with federal and local government as well as industry representatives. This meeting will facilitate discussion of the issues, action items and next steps required for the continued rapid expansion of the biofuels industry. USDA should then prioritize the items discussed and develop a roadmap of critical intervention, obtain stakeholder buy-in across both public and private sectors, and determine policy action and funding required to maximize the expansion of the biofuels industry in the United States.

USDA should then translate meeting results into action and policy movement, and develop a Management Plan to implement the actions according to their priority. Support should be generated across Departments and agencies to coordinate and fund the prioritized actions and Management Plan. Relevant USDA policy actions should be proposed for introduction in the 2007 Farm Bill.

Rationalizing the Regulatory Environment for Renewable Energy: Overcoming the Constraints to Rapid Growth in the Biofuels Industry

BACKGROUND AND SCOPE

The U.S. Department of Agriculture has tasked Booz Allen Hamilton to investigate an aggressive biofuels policy, which would result in industry production of 60 billion gallons per year (BGY) by the year 2025. This amount of biofuels would have the potential to meet up to 17% of the projected 250 BGY transportation fuel demand for 2025, on an energy equivalent basis.

The 60 BGY target represents what policymakers currently believe to be the most aggressive yet achievable goal for biofuel production (i.e., ethanol and to a lesser extent biodiesel) in the U.S. The goal is attainable, but will require significant technological, logistical and socio-economic changes to the current system.

Section I describes how the biofuels and energy industry might look in 2025, if the 60 BGY goal were achieved. Section II describes the benefits that could be achieved through aggressive biofuels production. Section III describes the current state of the biofuels industry; projects how the industry would look in an aggressive growth environment; describes the factors constraining that growth; and presents options available to address the constraints and achieve the projected future. Section IV describes the next steps need for government to operationalize the analysis presented in this report. A subsequent Appendix discusses the regulatory, tax and programmatic environment.

I. VISION OF THE FUTURE: 60 BGY OF BIOFUELS BY 2025

The year is 2025. The U.S. biofuels industry is producing 60 BGY which has met 17% of the projected 250 BGY transportation fuel demand for 2025, on an energy equivalent basis. The premise of a 60 BGY future implies a wide range of changes to the current system. Section I explores the characteristics and implications of a 60 BGY future.

Characteristics of a 60 BGY Future

Energy security has been increased significantly with the replacement of oil imports with locally produced biofuels from locally grown feedstocks.

The infrastructure necessary to establish and support the industry would be in place. This infrastructure would consist of facility construction and maintenance, and creation of a new national biofuels distribution network including pipelines and storage terminals. Ethanol and biodiesel are shipped through a system of pipelines from local refineries to central biofuels terminals and from there to regional suppliers, where they may be blended with petroleum fuels and shipped by truck to retail outlets.

Grain-based ethanol production long ago peaked at 15 billion gallons per year; supplemental technologies have maximized the ethanol yield from high-starch, high-yield corn. Cellulosic ethanol production technology is fully commercialized, and produces the majority of the remaining 45 billion gallons, using a variety of feedstocks including corn stover, wheat straw, and other agricultural residues; dedicated energy crops; logging and mill residues and forest fuel treatment thinnings; and the biomass portion of municipal solid waste. Cellulosic ethanol is produced in small-scale refineries located throughout rural America, near the production areas of a variety of feedstocks.

Biodiesel production has benefited from corn oil produced as a by-product of enhanced ethanol biorefining technology and from increased oil yield from modified soybean and canola crops. Biodiesel industry production, however, is still only a small fraction of overall biofuels production (by volume).

Biofuels are at least as cost competitive with petroleum-based fuels on a miles per dollar basis – and often cheaper. Cars and trucks are flex fuel vehicles (FFVs) that run on both biofuels and petroleum fuels. Fuel retailers have biofuels pumps, particularly E85 (or its replacement) and biodiesel. Educated consumers willingly purchase all of the biofuels produced.

Implications of a 60 BGY Future

National energy security would be greatly enhanced and U.S. foreign policy would be able to better align domestic energy demands with national security and military objectives.

Emissions of air pollutants and climate changing gases would be greatly reduced in comparison to 2006.

The U.S. trade deficit would be reduced by more than $80 billion dollars per year, or 25%.[1]

Agriculture would experience a significant increase in annual revenues from the production of energy crops. The total net annual income to rural America would have increased by as much as 32% to $12 billion.[2] The forest industry would receive significant revenue from conversion of waste and thinnings to cellulosic ethanol, and the cost of forest fires could be dramatically reduced.[3]

Growth of the biofuels industry would provide significant economic benefits to the rural community. Distributed biorefining throughout rural communities would create more and better-paying jobs. Local communities would benefit from increased per-capita income and strengthened local tax base. The economic stimulation of the support infrastructure within these

[1] According to the EIA, the U.S. imports more than 13.5 million barrels of oil per day in 2006, at a cost of $60 per barrel - this equates to more than $295.5 billion per year, almost 30% of the annual U.S. trade deficit.
[2] "Growing Energy: How Biofuels Can Help End America's Oil Dependence" National Resources Defense Council. Nathanael Greene. December 2004.
[3] According to the National Interagency Fire Center, the United States spent almost $876 million to fight 66,552 wildfires that damaged or destroyed almost 8.7 million acres in 2005.

communities would include construction of new schools, service industries, housing, and transportation.

Cellulosic ethanol plants would be dispersed throughout rural America where biomass feedstocks are available.[4] The ethanol plants would be completely powered by their own waste streams (lignin) and biomass. These waste streams would be dried, pelletized, and used to fuel the boilers that provide power to operate the biorefining process.[5]

II. Economic Benefits of Ethanol Production

Section II describes the economics of biofuels production and highlights the economic benefits produced by both corn-based and cellulosic-based ethanol and biodiesel. Benefits discussed include the creation of new jobs and increases to local, state and national economies.

Corn-based Ethanol Benefits

Processing corn products instead of exporting raw corn doubles the value of each bushel of corn. An ethanol plant which uses the dry mill process can produce 51.5 million gallons/year of ethanol from 18.1 million bushels of corn, generating 154,500 tons of distiller's dry grain as a by-product. In an ethanol plant of this description, the cost of generation per gallon of ethanol is $1.39. The largest operating costs are the material cost of corn feedstock (63%) and the energy (electricity and natural gas) needed for boiler fuel and grain drying (28%).[6] Table 1 details the 2006 operating costs of such a plant.[7]

[4] Due to the economics of biomass collection, ethanol plants would collect the majority of their feedstocks within a 50 to 100 mile radius. Based on available feedstock, the average grain ethanol plant would produce between 50 to 250 million gallons/year (requiring 18 to 90 million bushels of corn annually), while the average cellulosic ethanol plant would generate 150 to 300 million gallons/year (requiring 1,750,050 to 3,500,100 tons of biomass annually). Finished product is shipped through a local network of dedicated biofuels pipelines to a central biofuels terminal, where it is stored and consolidated, then shipped through larger nationwide dedicated biofuels pipelines to regional suppliers, where it may be blended with petroleum fuels and trucked to retail outlets.

[5] Energy needs include producing steam for drying the boiler fuel and running the distillation columns, and driving the turbine necessary to make the electricity to operate the pumps, controls and other peripheral devices necessary to operate the plant.

[6] Average prices of corn and DDG from USDA ERS (Jan-June 2006 average No.2 Yellow Corn in Central Illinois $2.11 per bushel and $0.10 transport charge), energy prices from EIA, wage rates from Bureau of Labor and Statistics.

[7] "Economic Impacts on the Farm Community of Cooperative Ownership of Ethanol Production", LECG, LLC, John M. Urbanchuk, September 2006.

Table 1 – 2006 Operating Costs of a 50 MGY Dry Mill Ethanol Plant

Raw Materials	Units/Gallon	Unit Price	Cost (Mil $/year)	Cost per Gallon
Corn (BU)	0.364	$2.21	$40.18	$0.804
Enzymes (lb)	0.035	$1.02	$1.79	$0.036
Yeast & Chemicals (lb)	1.126	$0.02	$0.84	$0.017
Denaturant (gal)	0.030	$2.00	$3.00	$0.060
Electricity ($/KWh)	0.800	$0.06	$2.31	$0.046
Natural Gas ($/MCF)	0.036	$8.46	$15.23	$0.305
Process Water (thou gal/bu)	0.010	$0.37	$0.18	$0.004
Waste Water (thou gal/bu)	0.008	$0.50	$0.19	$0.004
Direct Labor + Benefits ($.032/gal)			$1.60	$0.032
Maintenance & Repairs ($.026/gal)			$1.30	$0.026
GS&A ($.06/gal)			$3.00	$0.060
Total Costs			$69.63	$1.393

Source: Information based on LECG, LLC analysis

Taking into the economics of plants such as these, enhanced production of corn-based ethanol offers a number of benefits.

National benefits – It is estimated that the ethanol industry as a whole contributed $17.7 billion to the nation's Gross Domestic Product in 2005.[8] It was responsible for the direct creation of 19,000 jobs in the manufacturing sector and the indirect creation 153,725 jobs at large. The fiscal impacts were estimated to have exceeded $1.9 billion annually in federal tax revenue and nearly $1.6 billion of combined state and local government tax revenues.[9] These statistics represent the state of today's industry and would all grow substantially with a more expanded biofuels industry in the future.

State benefits – A recent study by Iowa State University economists estimated that once in production, Iowa's 14 existing ethanol plants and nine plants under development will contribute a total of $3.9 billion to the state's economy. It is further estimated that as a whole, Iowa's ethanol industry will contribute $16 million annually in state tax revenues and create 5,187 direct and indirect jobs within Iowa's economy.[10]

Household benefits - Ongoing annual operations of a 50 million gallon per year (MGY) ethanol plant are estimated to increase household income in the local economy by nearly $30 million annually. A 100 MGY ethanol plant will increase household income by more than $50 million.[11]

[8] "Contribution of the Ethanol Industry to the Economy of the United States", Urbanchuk, John M., LECG, LLC, February 21, 2006.
[9] "Contribution of the Ethanol Industry to the Economy of the United States", Urbanchuk, John M., LECG, LLC, February 21, 2006.
[10] "Economic Impacts of Ethanol Production, Ethanol Across America", Paul Gallagher and Dan Otto, Iowa State University, January 2005.
[11] "Contribution of the Ethanol Industry to the Economy of the United States", Urbanchuk, John M., LECG, LLC, February 21, 2006.

Local community benefits - The advent of 'New Generation Cooperatives' (NGCs) allows local communities to capture more of the benefits from biofuels production locally. The typical NGC funds and manages value-added ethanol plants, in contrast to previous cooperatives that were commodity clearinghouses for member products.[12] Local rural resident-owned ethanol plants improve the local economics of rural America more than absentee corporate-owned plants. While corporate-owned plants may use outside providers for administrative services and inputs supply (enzymes, yeasts, chemicals), rural resident-owned plants tend to derive these resources locally. For a 50 MGY ethanol plant, this equates to $4.9 million additional spending in the local community and a 6.6% larger contribution to Gross State Product.[13]

Numerous economic studies have estimated the increase in local corn price when an ethanol plant is built. The radius around an ethanol plant where it is cost-effective to transport the corn to the plant rather than sell it to the local grain purchaser is estimated to be 35-50 miles, but this varies significantly with local infrastructure and ethanol prices and some studies estimate it is 100 miles. The immediate direct benefit to local corn growers is the increased price of corn. Several studies have produced varying estimates from 10-12 cents per bushel, approximately half of which is consumed by increased transportation costs. Rural residents are estimated to receive 5-10 cents per bushel increased profit.[14] Every 100 acres of corn produced, at the national average yield translates into as much as $1,350 of incremental new revenue.[15]

Cellulosic Ethanol Benefits

The economic impacts of cellulosic ethanol production are less documented, but the benefits from the creation of a market for underutilized products including corn stover; wheat straw; crop, logging and mill residues; forest fuel treatment thinnings; and the biomass portion of municipal solid waste (MSW), are intuitive. The revenues generated from corn stover are estimated to be $35 per dry ton.[16] The other waste products that could be used to produce cellulosic ethanol would each have their own economic benefits in the form of reduced waste costs and increased revenues.

The capital costs for cellulosic ethanol plants are high due to the complexity of the conversion process, but would translate into additional initial benefits to the local economy. A report by the Northeast Regional Biomass program found that a wood-to-ethanol plant in the northeastern U.S. would generate between $170 million to over $200 million in income and create from 4,000 to

[12] "New Generation Cooperatives and The Future of Agriculture: An Introduction", Illinois Institute for Rural Affairs, Jennifer Waner, July 2001.
[13] "Economic Impacts on the Farm Community of Cooperative Ownership of Ethanol Production", LECG, LLC, John M. Urbanchuk, September 2006.
[14] "The Economic Impact of Ethanol Plants in South Dakota", Randall M. Stuefen, December 27, 2005
[15] Urbanchuk, John M., AUS Consultants; Kapell, Jeff, SJH & Co. June 20, 2002.
[16] "Determining the Cost of Producing Ethanol from Corn Starch and Lignocellulosic Feedstocks", Andrew McAloon, Frank Taylor, Winnie Yee, NREL/TP-580-28893, October 2000.

6,000 jobs in the short-term during construction. In the long term it would consistently provide $41 to $48 million per year in income, 540 to 830 jobs, and $1 to $3 million in state taxes.[17]

Biodiesel Benefits

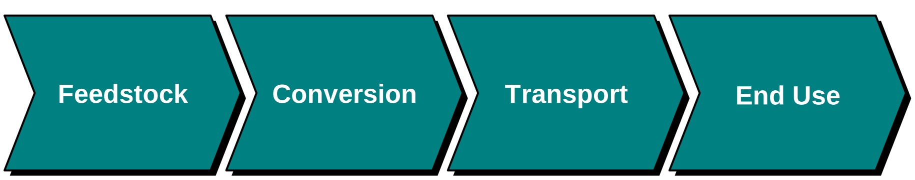
Assuming U.S. biodiesel production reaches 650 MGY by 2015, the biodiesel industry would add $24 billion to the U.S. economy between 2005 and 2015. Soybean process can be expected to increase by $0.58 per bushel by 2015. This industry expansion would create up to 39,102 jobs throughout the U.S. economy and keep $13.6 billion that would have been spent on foreign oil in the U.S. economy. Investment from biodiesel producers for expansion and construction of biodiesel plants between 2005 and 2015 would total nearly $810 million, and add $1.5 billion to America's Gross Domestic Product (GDP). Biodiesel industry expansion is likely to add an additional $15.6 billion to America's GDP as it spends $7.6 billion on goods and services between 2005 and 2015.[18]

III. THE BIOFUELS VALUE CHAIN: PROJECTED FUTURE, CONSTRAINTS, AND POLICY OPTIONS

Achieving the 60 BGY vision requires foreseeing constraints that could arise, and responding to each of these by developing and implementing programs that remove the constraint in a manner that results in an overall efficient production, storage, distribution and use system. When attempting to foresee these constraints it is valuable to analyze the biofuels industry as a series of steps in a value chain. For purposes of this analysis, there are four steps in the biofuels value chain: feedstock, conversion, transport, and end use.

Figure 1 displays these four components of the top-level biofuels value chain.

Figure 1



Section III describes the value chain required for cellulosic ethanol, including mention of both grain ethanol and biodiesel production requirements, and comparison with the petrochemical fuels value chain when helpful.

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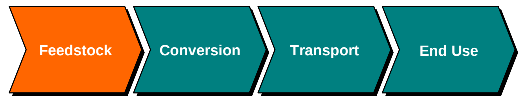
[17] "Economic Impacts of Ethanol Production, Ethanol Across America", Paul Gallagher and Dan Otto, Iowa State University, January 2005.
[18] "Biodiesel's Contributions to the U.S. Economy", LECG, LLC, John M. Urbanchuk, September 2006.

For each step of the value chain, Section III describes the status quo; projects the future status which is prerequisite to achieving the 60 BGY goal ("Projected Future"); describes the challenges which may constrain achievement of that goal ("Constraints upon Future Growth"); and offers alternatives to overcome those obstacles ("Policy Options").

The first step in the value chain is feedstock.

Feedstock



Feedstock production involves the growth and harvesting of both traditional crops such as corn and soy and future dedicated energy crops and biomass available from forest and agriculture resources. As biofuels production volumes continue to increase, existing resources will begin to limit expansion of the industry. Modifications to existing crops and introduction of dedicated energy crops, coupled with new collection and storage technologies, will be required to support the continued rapid expansion of the biofuels industry.

Counting existing and additional production capacity under construction, the U.S. ethanol biorefining industry will have a production capacity in excess of 7 billion gallons per year in early 2007.[19]

Corn - As corn production increases to meet future fuel demand, additional storage must be provided. Ethanol biorefining capacity doubled between 2002 and 2005, and forecasts suggest that capacity will increase by 57% between 2006 and 2007.[20] At this rate, feedstock availability may quickly become a limitation to expansion of the ethanol biofuel industry. Current grain ethanol technology has the ability to support approximately 15 billion gallons of annual grain ethanol production before significantly impacting both the price and availability of feed grains used for ruminant animal feed.

Cellulosic – As of 2006, cellulosic ethanol technology remains in the early stages of full scale demonstration and has not yet entered into industrial production or scale. Therefore, all ethanol generated in the U.S. is produced from grains, rather than cellulosic feedstock.

Biodiesel – Biodiesel annual production volume is expected to surpass 1.1 billion gallons based on current installed and planned additional biodiesel plant production capacity.[21] Biodiesel requires 7.5 pounds of oil for every gallon of fuel, translating to an annual demand in excess of 8.25 billion pounds of biodiesel feedstock, which equates to more than 33% of annual U.S. production of vegetable oil.[22] Three quarters of the currently operating U.S. biodiesel plants use soybean oil as feedstock. This severe limitation in volume of biodiesel feedstock must be

[19] Renewable Fuels Association (www.ethanolrfa.com)
[20] Renewable Fuels Association (www.ethanolrfa.com)
[21] National Biodiesel Board (www.biodiesel.org)
[22] "The Outlook and Impact of Biodiesel on the Oilseeds Sector", John C. Baize, USDA Outlook Conference, February 6, 2006.

overcome by increased oil crop production, new oil crop development (including high oil content corn strains and oil from algae) and oil imports for conversion to biodiesel.

Future of Feedstock

Increased volumes of traditional feedstocks, including corn and sugar crops such as sugar cane and sweet sorghum, must be grown to satisfy the ever-increasing demand for biofuels feedstock until new technologies are available which can take advantage of alternate feedstock sources. Market demand will stimulate the rural economy with increased revenues for crops that once relied on subsidies to remain profitable.

Corn - Improved crop strains focused on energy characteristics could possibly expand the volume of ethanol that can be produced from corn, as there have been significant improvements in the harvest yield of corn through selective breeding. Corn hybrids with high starch contents and increased yields will increase the ethanol volume produced per bushel of corn as well as the bushel yield per acre. Through selective breeding, similar improvements in yield could be realized for soy and canola crops. Additionally, if higher oil content were realized for soy and canola, this would also increase the oil yield per acre. The result of these improvements would be more oil for conversion. However, it is well accepted that the quantity of corn feedstock alone is insufficient to support ethanol production in excess of the 10% blending market. Therefore, in the future which makes possible 60 BGY, corn's contribution will necessarily be limited.

Cellulosic - Through cellulosic ethanol production, the biofuels industry will have the resources to expand to the point of replacing significant quantities of petrochemical transportation fuel. Initial feedstocks will be corn stover (not the grain portion current used, but the remaining corn crop biomass); wheat straw; crop, logging and mill residues; forest fuel treatment thinnings; and the biomass portion of municipal solid waste (MSW).

New, dedicated energy crops are the future of the cellulosic ethanol biofuels industry. Crops such as switchgrass are perennial, drought tolerant, require significantly less fertilizer, and have improved nutrient uptake characteristics. They can be grown on marginal land without the need for large scale pesticide applications. Additional energy crops that are under development include fast-growing short-rotation woody crops (SRWC) like hybrid poplar and willow. Agroforestry can be used to reduce concentrated livestock waste, pesticide and fertilizer contamination of surface and groundwater, and provide a sanctuary for plant and animal biodiversity. Timberbelts can provide rural economic diversification as a biofuels feedstock resource and windbreak, which can increase the yield of wind-sensitive crops and protect soil and livestock.[23] A portion of these crops could be harvested annually to provide cellulosic ethanol feedstock, while the rest is left to provide continued wind protection. Harvesting can be performed by cutting and chipping, providing immediate densification and ease of biomass storage. The remaining stumps will continue to re-sprout even after multiple harvests. Winter

[23] "Perennial Crops for Bio-Fuels and Conservation" Gregory Ruark, Scott Josiah, Don Riemenschneider, Timothy Volk, February, 2006.

harvest would allow a second collection of feedstock and reduce both feedstock storage volume and duration requirements.

Biodiesel - Through selective breeding, similar improvements in yield could be realized for soy and canola crops. Additionally, if higher oil content were realized for soy and canola, this would also increase the oil yield per acre. The result of these improvements would be more oil for conversion to biodiesel. There is ongoing research to increase the fuel yield from ethanol and biodiesel feedstocks through biological strain improvements.

<u>Constraints upon Future Growth of Feedstock</u>

Storage - More traditional feedstock must be available to sustain the growth of the current biofuels industry. Additional crops of corn, soy and canola must be planted and harvested to produce the feedstock necessary to support this expanding industry. Increasing the volumes of traditional feedstock growth and harvesting will strain on-farm storage capacity. Rural residents are already struggling to store excess grain yields from recent bumper crops, and due to the fact that harvests are normally annual or biannual and refineries need a constant supply of feedstock, the storage requirements will increase commensurate with the demand for these crops.

Risk management - Increased grain ethanol plant feedstock demand must be offset by increased feedstock production to avoid a spike in feedstock price that may negatively affect the cost of feed and have a ripple effect causing increased food prices. The situation could prove more critical in an expanded biofuels industry that requires significant volumes of dedicated energy crops. Severe drought and low crop yields could have significant impact on the feedstock availability for conversion to biofuels. Including corn grain, the estimated feedstock requirement for a 60 BGY ethanol industry is between 600 to 700 million tons of biomass annually.[24]

GMO opposition - Selective breeding of traditional feedstocks including corn, soy and canola can take multiple growth cycles. As these crops are annual, developing strains with the best characteristics for biofuels feedstock can take many years. Genetic modification of these crops would significantly reduce the time required for strain optimization for increased yield, drought and pest tolerance, and increased utilization of fertilizer. However, the by-products from biofuels conversion of these feedstocks are used for animal feed, and this livestock in turn either produces or become food for human consumption. Dedicated energy crops can also benefit from genetic modification, and they too have the opportunity to produce both sugars and proteins that can ultimately enter the food chain. However, there is much resistance to allowing genetically modified crops to enter the food supply, significantly increasing the development time for these modified crops. A lengthily certification process can delay the introduction of beneficial crops by multiple years. Additionally, certifying these crops for export can significantly lengthen time from development to introduction.

Underutilization of existing biomass - A great deal of biomass is available, sustainable, and currently goes unused. Stover can be collected from cornfields, residues that are currently left in the forest during tree harvesting can be collected along with forest thinnings, and switchgrass

[24] "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply", DOE/ORNL, April 2005.

and woody biomass energy crops can be grown and harvested. Utilization of these resources will require identification of appropriate conservation practices to maintain the agricultural and forest lands from which these resources can be harvested and environmentally sound harvesting and collection methods must be developed. Wood residues from the forest products industry and MSW biomass are currently collected and stored in specific locations, making these resources easier to bring to market as biofuel feedstock.

Feedstock transportation - Transportation cost for cellulosic ethanol feedstock is a contributing factor in the economics of a cellulosic ethanol plant. The general consensus among industry experts is that biomass transportation in excess of 50 miles could adversely affect the economics of a cellulosic ethanol plant. As these feedstocks are of low energy density, high volume, and from dispersed sources, it is necessary to develop economical means of collection, transportation, and storage of these materials to ensure the success of the cellulosic ethanol biorefining industry.

Feedstock storage for ethanol plant facilities - Cellulosic ethanol plants operate year round, but feedstocks like stover and switchgrass have specific harvest windows that are only a few months long. Coupled with the need to have a surplus to prevent shortages, a supply of 12 to 15 months of biomass should be stored for each cellulosic plant, and methods for preserving the feedstock during long-term storage have yet to be developed.

Alignment of land use with energy goals - Growing energy crops like switchgrass can prove to be economically beneficial for the rural residents due to demand for both the crop and the protein rich feed by-products created in the biorefining process. However, the investment takes time due to the one- to two-year window between the initial planting and first harvest for switchgrass, the three-year growth to harvest cycle for willow, and the seven year growth cycle for poplar. The time necessary to convert to an alternative energy crop can be rather lengthy, and the economic hardship to the rural American might be difficult. The changeover may require a stepped transition to switchgrass or SRWC to maintain continued income for the rural resident.

Stewardship and CRP - Other land resources such as conservation lands contained within the Conservation Reserve Program should also be considered as potential land resources for the development of energy crops. There are issues with the use of conservation lands (e.g., forests being harvested incorrectly or being damaged) that must be addressed to ensure that the development of biomass for cellulosic ethanol production does not damage the current ecosystem balance. Current re-enrollment of CRP land is high and there is no incentive for land reintroduction for growing dedicated energy crops. However, even if all grain crop yields were increased by 50% and 75% of all crop residues were collected, there would still be the need to dedicate a minimum of 30 million acres of cropland, idle cropland, and cropland pasture to the production of energy crops to achieve 60 BGY of biofuels production.[25]

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[25] "Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply", DOE/ORNL, April 2005.

Policy Options to Overcome Constraints upon Feedstock

A mechanism should be created to determine what future agricultural practices must be present in 2025 to support a 60 BGY biofuels market and still meet food and feed requirements.

This study should examine the balance between existing agriculture and introduction of new energy crops and the pace of land introduction and/or conversion needed to meet future biofuels production targets.

Additional research and development programs could be undertaken by both universities and government agencies to support the increased production of both traditional and non-traditional/cellulosic biofuels feedstock.

Increased funding for both traditional and cellulosic feedstock research and development will have significant impact on improving the economics of biorefining. Feedstock is the single largest cost associated with biorefining. By increasing feedstock yield per unit of land growth area and biofuel yield per unit of feedstock, the overall price of finished biofuels can ultimately be reduced, in turn lowering the cost of biofuels to the consumer. Alternative feedstock sources should also be researched. Potential oil crops including palm and algae contain the capacity for significantly higher oil yields per acre than traditional soybean feedstock and have lower pesticide, nutrient and irrigation requirements.

The government should consider providing carbon sequestration credits for the production of biofuels feedstock in order to level the playing field with petroleum.

Policy could encourage emerging carbon markets to develop mechanisms to allow the producers of biofuel crops to obtain payments for sequestering carbon. Further research into the amount of carbon sequestered by various biofuel feedstock crops may be necessary to facilitate the development of these rural resident-friendly carbon offset policies.

The government should examine the potential of creating some form of strategic crop reserve as a hedge against lost production capacity due to low crop yield.

Crop yield variability and drought cycles need to be determined in potential feedstock growth areas to assess the possible impact of both seasonal yield variability and one in 10 and one in 100 year drought cycles. The logistics of maintaining annual biomass availability of 600 to 700 million tons and the amount of stored reserve required to support the ethanol industry in times of lean biomass production require significant research and planning.

The government should develop programs to fast-track the development and introduction of hybrid and genetically modified crops.

> Streamlining the certification process for genetically modified organisms (GMOs) could have a significant impact on the amount of feedstock available for biofuels production. Export regulations should be studied relative to their impact on the development of the U.S. biofuels industry. Updating the certification of genetically modified crops should be considered in light of the recent advances in biological sciences that have the potential to revolutionize the agricultural industry.

Subsidies similar to those for traditional crops should be enacted to encourage the production of new feedstocks with the same protection afforded to traditional crops including risk management tools guaranteeing price and providing crop insurance.

> Additionally, some traditional subsidy payments could be moved to fund insurance which could cover growers of energy crops, while others could be modified to encourage growth of energy crops. The continuation of land use subsidy payments could be restructured to require energy crops to be grown if the land is not in use. Modifying these farm subsidies could help rural residents overcome the uncertainty inherent in the transition from growing a known commoditized crop, such as corn or soy, to an unknown energy crop.

The government should fund studies to research densification of biomass on-farm and other ways to reduce feedstock shipping costs associated with truck and rail transport of feedstocks from farms to the conversion plant.

> Such studies could also support the identification and minimization of feedstock transportation impacts on rural society. Government protection for existing rail lines may be required to keep them operational for use in transport of biofuels and biofuel feedstock. Research should be funded to determine the best consolidation and storage options for cellulosic biomass. Any feedstock cost reduction has a significant impact on reducing the overall cost of biofuels production.

Government-funded research should be conducted to determine best practices for harvesting biomass from no-till fields and forests.

> Currently, there has not been a strong push to develop a harvesting management methodology that protects the ecosystem, regulates the amount of biomass that is removed from the system and defines the amount that must remain in place to protect the landscape from erosion and nutrient loss. Methods of extraction should be developed to sustain the system and ensure that the surrounding landscape is not damaged during the collection of biofuels feedstock.

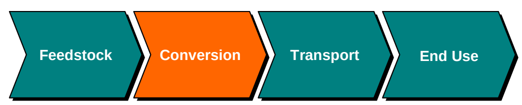
Research should be performed to determine the amount of CRP land that has the potential to be used for different types of feedstock based on harvesting economics and crop water and soil requirements.

Land availability for expanded production of both traditional and new biofuels feedstocks may become scarce with the large demands required by the rapid expansion of the biorefining industry. Significant land areas are set aside by the Conservation Reserve Program (CRP). Effective incentives for encouraging landowners to reintroduce CRP land for energy crop production should be determined and implemented.

Credits for carbon sequestration through the production of biofuels could also serve to level the playing field with petroleum.

Carbon sequestration involves capturing the carbon dioxide produced during the manufacture of biofuels and injecting it into geologic formations or aging oil wells, preventing the release of greenhouse gasses to the atmosphere. Emerging carbon markets could be encouraged to develop mechanisms to allow the producers of biofuel crops to obtain payments for sequestering carbon which is trapped in the soil and root structure of biomass and thus removed from the atmosphere. Further research into the amount of carbon sequestered by various biofuel feedstock crops may be necessary to facilitate the development of these rural resident friendly carbon offset policies.

Conversion



Ethanol and biodiesel plants each have their own unique processes for converting renewable feedstocks into biofuels. Both industries have established methods for conversion. However, new technologies must emerge which can convert different and more plentiful renewable resources into biofuels. Both current and future technologies able to efficiently produce biofuels from a wide variety of feedstocks will be required to establish a sustainable American biofuels industry capable of replacing a significant amount of imported oil.[26]

Ethanol - There are 110 ethanol plants currently operating in the U.S. with a combined production capacity of 5.4 BGY. Another 73 new facilities currently under construction and 8 existing facility expansions will increase this production capacity to 11.4 BGY by 2009.[27] Most of this ethanol is currently produced from corn-derived starch.

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[26] The significant influx of new funding necessary to support the construction or expansion of these ethanol plants demonstrates significant investor confidence in the long-term viability of the U.S. ethanol industry. According to the article "Ethanol Plant Construction" in the October 2006 edition of *Ethanol Producer Magazine*, within this industry, 85% of process technology and construction is being handled by the top five companies; ICM Inc., Fagen Inc., Delta-T, The Industrial Company/T.E. Ibberson, and Broin Companies. Plant developers must be experts in both technology and management in order to ensure long-term project success. Demonstrated by the bulk of new construction being handled by the top five companies in the industry, investment trends focus on selection of ethanol plant developers with a proven track record of successful past performance.

[27] Renewable Fuels Association (www.ethanolrfa.org)

Due to their lower cost of construction and lower energy requirements, over 80% of new ethanol plants are "dry mills." Dry mill technology produces sugar from enzymatic conversion of starch from corn, followed by enzymatic conversion of corn starch to sugars. These sugars can be sold as sweetener or fermented with additional enzymes to ethanol, which can then be distilled into fuel grade ethanol. The by-product is distiller's dry grain (DDG), which is sold as cattle feed. Many ethanol plants are strategically located near cattle farms to minimize DDG transportation costs.

Ethanol facilities using "wet mill" technology separate the germ (oil), fiber, and protein from the corn starch prior to enzymatic fermentation to ethanol. Though more capital-intensive to construct with higher power demands, a wet mill plant is still more economical to operate due to the high value of co-products that are also brought to market. Wet mill co-products include sugars, ethanol, starches, germ (corn oil), dextrins, and bran.

Biodiesel - There are 85 biodiesel plants currently operating in the U.S. with a combined production capacity of 580 MGY. Another 65 new facilities currently under construction and 13 existing facilities currently under expansion will increase the production capacity to 1.9 BGY within the next 18 months.[28] The significant influx of new funding demonstrates significant investor confidence in the long-term viability of the U.S. biodiesel industry. Most U.S. biodiesel is currently produced from soy, using the transesterification biorefining process. By volume, 80% of biodiesel by-product is crushed bean "cake," which is usually sold as a high protein animal feed. The remaining 20% of by-product, which is glycerin, is sold for use in soaps and pharmaceuticals. As biodiesel production increases, additional uses will have to be developed to prevent glycerin from becoming a large waste disposal expense.

CO2 Emissions - Biorefining and biofuels provide significant reductions in atmospheric greenhouse gas emissions compared to traditional petrochemical transportation fuel refining and use. Compared to gasoline, current commercial grain ethanol conversion processes reduce the "well to wheels" CO2 emissions by 20% to 40%, while cellulosic ethanol production technologies are projected to reduce greenhouse emissions by 70% to 90%.[29] Compared to conventional diesel fuel, current commercial biodiesel conversion processes reduce the "well to wheels" CO2 emissions by 40% to 60%.[30] However, biorefining still produces significant atmospheric CO2 emissions. A 50 MGY grain ethanol plant will produce annual CO2 emissions of 108,000 tons when using natural gas as process fuel, and as much as 207,000 tons when using coal as process fuel.[31]

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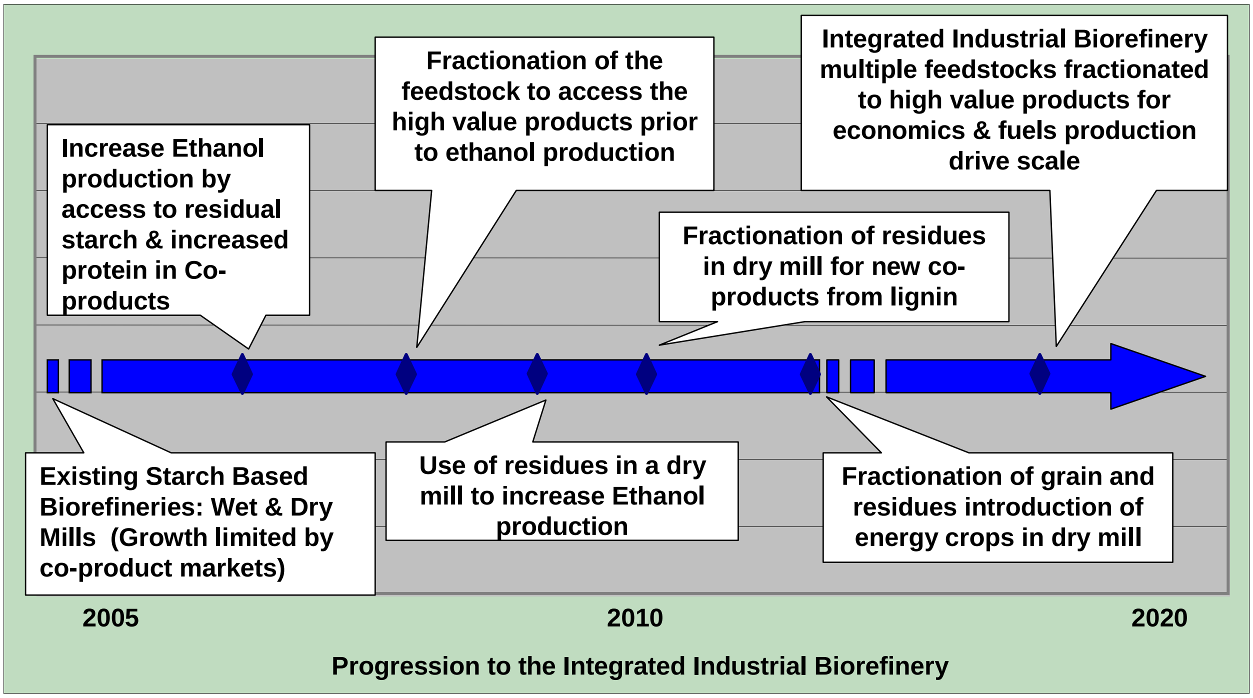
[28] National Biodiesel Board (www.biodiesel.org)
[29] "Biofuels for Transport; An International Perspective", International Energy Agency, Office of Energy Efficiency, Technology and R&D, 2004.
[30] "Biofuels for Transport; An International Perspective", International Energy Agency, Office of Energy Efficiency, Technology and R&D, 2004.
[31] "Report: Coal-Powered Ethanol Plant CO2 Emissions 92% Higher than Gas-Powered", Green Car Congress, November 25, 2006.

Projected Future of Conversion

Increased focus on by-products is required to improve overall project economics, as shown in Figure 2.

Figure 2 – Progression to Integrated Industrial Biorefinery



Source: Information based on NREL analysis

Fractionation technology increases both ethanol yield and DDG protein values - Second generation dry mills can incorporate fractionation[32] to produce higher-value co-products in addition to higher value DDG. With fractionation, a lower volume of a higher protein value DDG is produced, enabling it to supplement 25% of cattle feed, rather than the historic 10% of traditional DDG. Additionally, the higher protein content of enhanced DDG enables it to be used as poultry and swine feed. Fractionation increases the ethanol output from a traditional grain ethanol plant while reducing the enzyme requirements for the process. Dry fractionation is also an add-on technology for existing dry mill ethanol plants.

Cellulosic ethanol production technology added to traditional dry mill ethanol plants - In this process, some of the cellulose and hemicellulose will be removed from the DDG and

[32] With fractionation, the corn is separated into multiple co-products, including the endosperm, germ and fiber, each of which is then used based on the highest product value. High-value food-grade corn oil is removed from the starch, and subsequently the endosperm is converted into ethanol. Germ meal is a high-value animal feed that can substitute traditional grain diets. According to the article "Food and Fuel: A Lifetime of Innovation" in the October 2006 edition of *Ethanol Producer Magazine,* Broin Companies has developed a proprietary dry fractionation technology, BFrac, while ADM uses a wet fractionation process. According to a Broin press release on Project Liberty, their fractionation technology was developed through a five-year collaboration with the National Renewable Energy Lab (NREL) and South Dakota State University and was co-funded by the Department of Energy.

converted to sugars. These sugars are then fermented into additional ethanol and distilled. The result is a lower volume of enhanced DDG and additional ethanol volume. This option shows the most promise for demonstrating commercialization of cellulosic ethanol production, because it is the least capital-intensive approach. The feedstock will be uniform and pre-processed, allowing for enzymatic hydrolysis and conversion of the cellulose and hemicellulose to sugars. From this point the sugars can be fermented and distilled with existing plant hardware. The cellulosic ethanol trains that are piggy-backed onto existing grain ethanol plants can use stover from the farms that supply them grain to increase their ethanol production and permit process optimization for conversion of stover to ethanol. Additional cellulosic feedstock resources in close proximity to these plants can be used to optimize the cellulosic ethanol conversion process for biomass other than stover.

Investment community confidence in cellulosic ethanol - Numerous first-mover projects[33] that are funded and under construction demonstrate that the investment confidence necessary to build needed infrastructure is continuing to coalesce.

Ethanol plant as actual biorefinery - The role of ethanol plants will evolve from mere production of ethanol fuel, to being a facility in which fuels, feeds, chemicals and power all are produced from biomass. Ultimately, higher-valued co-products including bio-based chemicals and plastics can be derived from succinic, lactic and other organic acids produced during the conversion of bio-based feedstocks to ethanol. In the future, biodegradable bio-based chemicals and plastics will likely replace those made from petrochemicals. Both NatureWorks, LLC and DuPont are currently producing fibers and plastics from bio-based resources. Due to the high market value of these products, production and sale of organic acids and bio-based products could significantly increase the economics of biorefining when compared to revenues from ethanol sales alone.

Gasification of biomass and municipal waste – Gasification can be used to produce synthetic transportation fuels and other valuable co-products. In the gasification process, carbon-rich materials are heated to the point of vaporization in an oxygen-starved environment. The gas produced, syngas, contains mostly hydrogen and carbon monoxide. This syngas can be converted with special catalysts to synthetic diesel via Fischer Tropsch technology, or to ethanol

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[33] For example, Clearfield County, Pennsylvania, will soon be home to a 108 MGY corn ethanol plant, coupled with a $70 million pilot-scale cellulosic ethanol plant using locally available organic waste feedstock. Green Star Products is building the first CO2 neutral biodiesel plant in Idaho, with an on-site cellulosic ethanol research facility. Broin Companies, in partnership with DuPont, are implementing Project Liberty to convert a 50 MGY dry mill ethanol plant, Voyager Ethanol, located in Emmetsburg Iowa, to a 125 MGY commercial scale cellulosic ethanol biorefinery to begin commercial cellulosic ethanol production in 2009. At an expansion cost of $200 million (with up to $80 million coming from a DOE grant), this upgraded facility will use advanced corn fractionation and lignocellulosic conversion technologies to produce ethanol from both corn fiber and corn stover. The benefits of Project Liberty will be 11% more ethanol from a bushel of corn and 27% more ethanol from an acre of corn utilizing a production technology that reduces the energy requirement of the corn ethanol plant by 83%. Feed co-products from this process include annual production of 100,000 tons of germ meal and 120,000 tons of enhanced DDG. Additionally, Blue Fire Ethanol Fuels, Inc. has a patented technology for converting urban and other cellulosic waste and feedstock materials to ethanol. They recently advanced to the next stage of their DOE funding application for the construction of a 24 MGY cellulosic ethanol plant in Southern California which would convert 700 tons per day of green and other cellulosic waste into fuel grade ethanol.

and other alcohol transportation fuels through various proprietary technologies.[34] The gasification process produces large amounts of steam during the cooling and conversion of syngas. This steam can be converted to electricity with a turbine to run the process, and a significant amount of the power produced, up to 60% or more depending on process design, is excess and can be sold back to the grid. Multiple forms of these technologies have been demonstrated on a pre-commercial scale.

Constraints upon Future Growth of Conversion

Environmental challenges - Air emissions, waste production, and water requirements are large obstacles that must be addressed prior to the construction of a new plant; local state and federal permitting and site requirements must be considered. The use of fossil fuels to power most existing biofuels plants feeds the argument that these plants are not environmentally friendly or energy-efficient due to large energy demands. However, new cellulosic ethanol biorefining technologies can use the waste product of the process, lignin, to power the boilers that produce the heat and electrical power (through turbines) required to power the biofuels plant. This advance significantly reduces the carbon emissions generated, and closes the carbon cycle. A future carbon-constrained industry would need to mitigate carbon emissions, and air pollution will always need to be controlled. Waste production will differ based on biorefining technology and must be addressed early in the process design phase. Water requirements and wastewater treatment are significant concerns during facility site selection and permitting. All biorefining processes are water-intensive. The ratio of water required to ethanol produced in a traditional grain ethanol plant is one to one. A projected cellulosic ethanol plant will require two parts water to one part dry biomass feedstock and will recycle 95% of the water used. A 5,000 dry ton per day ethanol plant would require the addition of 1,700 gallons of water per minute and discharge 280 gallons per minute of wastewater.[35]

Skills - There is a lack of operational expertise in biorefining. Such expertise could become a limitation to extensive growth of the industry, and more scientists, engineers and operations managers are needed in order to ensure continued development of the U.S. biorefining industry.

Food demand - Additional demand on traditional crops such as corn and soy for use as biofuels feedstock has raised concerns of a future food vs. fuel crisis. This increased demand has some experts predicting a future shortage of animal feed and a subsequent spike in the cost of all associated food products. Increased crop yields, fractionation and enhanced DDG production are predicted to significantly increase the percentage of by-product feed available for animals. This high-quality feed is more digestible than traditional DDG and capable of meeting a higher percentage of the feed ration for cattle and dairy livestock, as well as pigs and chickens. Cellulosic crops used as feedstocks for biofuels can also produce high protein animal feed by-products, and additional enhancements to biofuels conversion technologies will continue to

[34] As examples: CHOREN Industries (www.choren.de), in conjunction with Daimler Chrysler AG and Volkswagen AG, has commercialized a gasification/catalytic technology which produces a synthetic diesel called SunDiesel; Power Energy Fuels, Inc. (www.vistainternational.net) has developed a catalytic technology for producing a high grade alcohol fuel called Ecalene from syngas; BRI Energy, LLC.(www.brienergy.com) developed a process which uses bacteria to convert the carbon monoxide contained in syngas to ethanol.
[35] "Growing Energy: How Biofuels Can Help End America's Oil Dependence", National Resources Defense Council, Nathanael Greene, December 2004.

develop improved forms of animal feed by-products. There is promise of developing long-term sustainability of the biofuels industry while continuing to satisfy animal feed requirements.

Cellulosic technology development - The technology for cellulosic ethanol production has not yet been commercialized. A number of companies have announced plans for large scale cellulosic ethanol production, including Iogen, Xethanol Corporation and Broin Companies. However, there are still arguments among industry experts as to which cellulosic biorefining technology is most appropriate for large-scale commercialization. Pre-processing to separate cellulose and hemicellulose from the lignin to produce C5 and C6 sugars for fermentation into ethanol is being performed with technological approaches including steam explosion, dilute acid hydrolysis, ammonia fiber explosion, mechanical separation, and organic solvents.

Private sector investment - There is a list of possible technologies, with pros and cons to each, but no definite leader in the race. Until one technology emerges as a clear winner, large-scale investment will be perceived as risky by investors. Cellulase enzymes are an integral part of current cellulosic ethanol production, no matter which pre-treatment technology is chosen. Cellulase enzyme cost has been a big issue for cellulosic ethanol production, limiting favorable economics for this biorefining technology.

Immature consolidated bioprocessing technology - Consolidated bioprocessing, possibly the most promising future biorefining technology, is also the furthest from commercial development. Consolidated bioprocessing refers to using recombinant DNA technology to produce a single genetically modified organism that can perform cellulose production, cellulose hydrolysis, hexose fermentation, and process fermentation. Maintaining sufficient yields of ethanol output is the key. Biological conversion technology reduces the cost of cellulosic ethanol production significantly, while minimizing the complexity of process waste streams, and having one organism that can do it all will simplify the process steps. This could be the technology that significantly reduces the overall cost of ethanol to a price point below $50 per barrel of oil equivalent.

Time-consuming regulatory compliance - In order to meet the production requirement of 250 million gallons of cellulosic ethanol by 2013, the commercialization of these facilities must begin now. Once an investment decision is made, it takes time to satisfy the regulatory and permitting requirements and obtain relevant government assistance. Through the 2005 Energy Policy Act, the Department of Energy (DOE) has been authorized to provide $250 million in loan guarantees for cellulosic and municipal waste ethanol plants and $1.05 billion in cellulosic biomass ethanol grants. However, the DOE is moving slowly; no loan guarantees have been issued to date. See Appendix A for more detail on these grants and loan guarantees.

High cost and large economies of scale for profitability - The high cost of gasification and Fischer Tropsch conversion and the large economy of scale required for profitability of these technologies must be reduced to enable their efficient use by the rural resident for biofuels production. This technology has the advantage of producing renewable diesel and other transportation fuels from a wide variety of feedstocks. The ability to efficiently convert feedstocks into a wide variety of renewable fuels with currently developed technologies would seem promising, but the costs of implementing these technologies in rural America is currently prohibitive.

Disruption of the corn-to-cellulosic transition in ethanol - Eventually new technologies will supersede the traditional methods of biofuels production. When cellulosic ethanol production is fully commercialized the economics of this process may be far better than that of grain ethanol production. At this point the existing grain ethanol plants will have to either adapt or close. Recognizing and averting this eventuality will require forethought into development of technologies that will either keep grain ethanol competitive or allow for inexpensive facility conversion to accept cellulosic feedstock.

Oil price volatility - At current crude oil prices of $50 per barrel, ethanol production is competitive. However, many remember the unmet expectations of the ethanol industry in the aftermath of the oil embargoes of the 1970s. During that period, billions of dollars were invested in a range of alternative fuel sources, most to be lost when world crude oil prices came crashing down. Memories of that experience contribute to increased risk premiums on all advanced energy projects and continue to stall progress in overcoming our oil import situation. Investments in ethanol production require lengthy periods to achieve the desired return on investment. During this period, there must be some assurances that crude oil prices will not again undermine the emergence of this industry, in order to prevent investment uncertainty from discouraging needed investment.

Short duration VEETC - Among the EPAct of 2005 ethanol production incentives designed to encourage the expansion of biofuel production in America is the Volumetric Ethanol Excise Tax Credit (VEETC). This credit provides a $0.51 tax credit per gallon of ethanol blended into gasoline, recently extended through the end of 2010. There is a similar credit for biodiesel blenders, good through the end of calendar year 2008. It provides a $1.00 per gallon blenders tax credit for each gallon of agri-biodiesel (biodiesel made from virgin agricultural products) added to petroleum diesel to form a biodiesel blend, and a $0.50 per gallon blenders tax credit for each gallon of biodiesel (made from other feedstocks including used cooking oil, tallow, and grease trap waste) added to petroleum diesel to form a biodiesel blend. These tax credits are refundable to petroleum companies who produce petrochemical transportation fuels. Every gallon of gasoline is taxed at $0.184, and every gallon of diesel is taxed at $0.244. A 10% blend of ethanol in gasoline (E10) reduces the petroleum refiner’s tax burden on a gallon of gas by $0.051, while a 10% blend of biodiesel in diesel (B10) reduces the petroleum refiner’s tax burden on a gallon of diesel by $0.050 when made from recycled feedstock, and $0.10 when made from virgin oil feedstock. These tax credits are a significant encouragement for the blending of biofuels into traditional petrochemical fuels. However, they are short duration credits (extension is not guaranteed) that can not be relied upon when evaluating the economics of a new biorefinery.

Policy Options to Overcome Constraints upon Conversion

The government should examine ways to align states' water use and air permitting goals and requirements with the federal goal of expanding the biofuels industry.

Expansion of the biorefining industry must not come at the expense of pollution to air, land or water. Water resource requirements will be a determining factor for both siting and waste treatment requirements. Rural communities must not have their municipalities overtaxed or significant portions of their water resources diverted to support a new biofuels plant. Environmental impact studies could be used to determine the resource requirements and pollution generated from both existing and new biorefining technologies. Research should be conducted to determine what lessons can be learned from the experience of the Clean Air Act Amendments of 1992.

The government should fund long-term programs (beyond five years) for the development of the biofuels industry.

Long-term programs would promote industry sustainability and encourage both increased private investment and research. Additionally, current loan guarantees and grants established by the 2005 Energy Policy Act in support of the biofuels industry might be utilized more efficiently. A government research project should be conducted to determine the most effective way to encourage investment in new biofuels technologies by leveraging the investment risk protection afforded by these loan guarantees and grants.

The government should encourage and support educational programs in biofuels.

Education is paramount to continued biofuels industry expansion. Degree programs in Land Grant Universities would develop experts in biorefining and accelerate technical progress in the industry as a whole. Careers might be based on biorefining technology research and development, biofuels related genetic research, process integration, and plant management. All of these areas lack the significant quantity of experts necessary to support today's expanding biorefining industry. Poised as an extreme growth industry, and with continued government support, biorefining would attract bright, ambitious and motivated individuals. This step may prove to be a prerequisite for the long-term success of the biofuels industry. New thinking and beliefs could serve as the catalyst for a paradigm shift through an approach that traditional experts might have discounted as impossible.

Continued government funding of technology research and encouragement of commercial–scale demonstration facilities may be the best approach to developing a commercialized cellulosic ethanol biorefining process.

As technologies are further developed towards commercialization at yields more closely resembling scaled-up design, the real hurdles and benefits of each technology become more apparent. Assumptions made from smaller-scale demonstrations may prove to be off target in commercial-sized demonstration facilities. Larger facilities can take advantage of a wide variety of feedstocks based on geographic location, and the result will be a more proven technology positioned for success when taken to a full commercial scale.

Additional research and development should be funded to lead to even further cost reductions and increased economics of ethanol production.

The DOE has funded research projects at enzyme manufacturers including Genencor and Novozymes Biotech, and the results are a recently achieved thirty-fold reduction in enzyme cost from $5.00 per gallon of ethanol to between $0.10 and $0.30 per gallon of ethanol. However, enzymes are still a large cost associated with cellulosic ethanol production when compared to their cost for grain ethanol production ($.036 per gallon). Additionally, existing grain ethanol plants could be converted from natural gas to biomass power to reduce the high energy cost incurred when using natural gas for grain ethanol production.

The government should encourage developers to piggy-back pilot cellulosic production technology projects onto existing ethanol plants.

This would facilitate demonstration of new technologies while minimizing necessary capital investment. Pilot facilities could be sited in strategic locations based on the types of feedstocks available in close proximity to existing ethanol plants. These existing ethanol plants would benefit from government assistance for pilot facility construction, while supplementing the volume of ethanol they produce. This approach could help ethanol plants to meet the 2013 federal requirement of 250 million gallons of cellulosic ethanol for transportation fuel while foregoing the capital investment necessary for standalone facilities during this technology's infancy. These ethanol plants would also gain the technical expertise necessary to expand their businesses once they develop new cellulosic ethanol production methods. Having a demonstrable working cellulosic ethanol biorefining process on-site is a sure way to prove the concept and secure the funding necessary to build a commercial cellulosic ethanol plant.

Gasification technology development for liquid fuel production should have increased government funding as it is fully developed for coal and can readily accommodate other resources such as municipal waste and biomass.

Research into lowering the cost of syngas conversion could quickly establish a large renewable fuel supply utilizing existing feedstock sources without the need to rely on significant technological development of processes that have yet to be proven on a commercial scale. Gasification is a commercialized process, and several companies have developed conversion technologies to transform syngas to synthetic transportation fuels. These technologies are not feedstock specific and can produce synthetic fuels that will likely be easier to assimilate into the existing transport infrastructure and easier to use with existing vehicle architecture than biofuels.[36]

As new biorefining technologies develop and traditional biofuels production technologies become economically constrained, the government should intervene with support for ethanol plant conversion to increase profitability.

The government should work closely with and consider incentivizing early mover facilities to incorporate emerging technologies and processes that will help keep them price competitive.

The government should determine the impact of states' carbon trading programs on development of the biofuels industry.

As individual states develop their own carbon trading programs and limit atmospheric release of greenhouse gas emissions, regulatory requirements may be enacted that affect the expansion of the biofuels industry. The government should consider developing national environmental policies with respect to greenhouse gas emissions from biorefineries.

The government should consider creating a biofuels security subsidy with a price floor on oil and a price ceiling in feedstock outside of which government support would be triggered to maintain positive economics within the biofuels industry.

This trigger amount should be established to ensure a reasonable rate of return on ethanol plant investments but would not come into effect until and unless world oil prices dropped below a certain level or feedstock prices exceeded a certain level. Considering the amount the U.S. spends on imports, nearly $320 billion a year, a moderate trigger price would be a bargain to the U.S. economy. In addition, rather than being sent overseas to fund economic development and other purposes of our trading partners, this money could go to rural communities in this country. This economic support is an even greater boon when considering the multiplier effect, or the trickling down of money through the economy.

The government should create Renewable Fuels Standards specific to E85 and biodiesel.

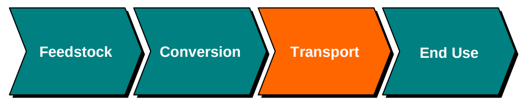
The existing RFS is totally met by the production and sale of E10. It does not encourage production of biodiesel or blending of E85. If a RFS was created for biodiesel, a significant and rapid expansion of the biodiesel industry would be likely, as was driven in the ethanol industry by the current RFS. Additionally, an E85 specific RFS would drive the blending and sale of significant volumes of E85 and support continued rapid expansion of the ethanol industry.

[36] Synthetic diesel can be shipped in existing pipelines and used in existing diesel vehicles without modification.

The government should extend long-term or make permanent the VEETC and biodiesel tax credit.

The existing VEETC and biodiesel tax credit are significant contributors to the positive economics of the biofuels industry. However, they are short duration tax credits. If these credits were extended long-term or made permanent they could be relied upon and factored into the economic equation of biorefineries. Permanent blender's tax credits would support continued rapid expansion of the biofuels industry.

Transport



Petroleum Transport - One hundred and forty six petroleum refineries[37] currently operating in the United States consolidate finished products in tanks for distribution via the product transportation network. The refined products pipeline system consists of approximately 72,000 miles of line and carries over 50% of finished petrochemicals to market.[38]

Both crude and refined petrochemical power fuels are shipped throughout the U.S. It is estimated that oil pipelines carry 68% of domestic petroleum shipments, over 14 billion barrels per year (many volumes are shipped as both crude and refined products, accounting for pipeline shipments exceeding annual consumption). The remaining shipments are by boats (27%), trucks (3%), and rail (2%).[39] Transportation mode is largely determined by cost, and pipelines have the most favorable economics (less than 3% cost increase to consumer per gallon[40]), making them the method of choice for shipping oil and refined petrochemical products throughout the nation's interior.

Regional supplies are stored in bulk fuel terminals with capacities ranging from a few small tanks storing 50,000 barrels to many large and small tanks storing millions of barrels of finished products. Terminals may store gasoline and diesel fuel only or an assortment of refined petrochemical products as well as biofuels. Currently there are 1,500 finished product fuel terminals in the United States shipping finished product to 168,933 retail outlets.[41] Regional suppliers ship to retail outlets mainly by truck and to a small extent by rail. These retail outlets, with two more tanks for fuel storage, sell three grades of gasoline, may offer diesel and kerosene, and some offer biofuel blends as well.

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[37] "Update of Tables and Figures from U.S. Petroleum Refining and Gasoline Marketing Industry", Energy Information Administration (www.eia.doe.gov).
[38] "Petroleum Storage and Transportation, Volume V – Petroleum Liquids Transportation", National Petroleum Council, April 1989.
[39] "Shifts in Petroleum Transportation", Association of Oil Pipe Lines, 2000.
[40] "How Pipelines Make the Oil Market Work – Their Networks, Operation and Regulation", Allegro Energy Group, Cheryl J. Trench, December, 2001.
[41] Energy Information Administration data on retail outlets as of 2005: (Compiled data from EIA, Bureau of Census, National Petroleum News: "Market Facts 2004"; www.eia.gov).

Ethanol Transport - Ethanol is primarily shipped from the plant directly to the bulk fuel terminals. Approximately one third of ethanol is shipped by each mode: water (barge or ship), rail and truck. Ethanol is not currently shipped via pipeline. The economics are not currently profitable for pipeline companies to build a dedicated pipeline network to carry ethanol due to the small volumes that would currently benefit from pipeline shipment. Additionally, concerns over ethanol characteristics (including its affinity for water and its corrosive properties) and the possibility of stress corrosion cracking prevent the ready conversion of traditional multi-product petrochemical pipelines to ethanol distribution systems.

When transporting larger ethanol shipments over greater distances, the economics for waterway (barge and ship) and rail prevail over truck transport. Estimates for ethanol shipping cost varies from $0.02 to $0.04 per gallon for ship and ocean barge, $0.08 to $0.16 per gallon for barge, $0.035 to $0.145 per gallon for rail, and $0.035 to $0.065 per gallon for truck (trucks are only used for short distance shipping due to significant cost increases over long distances – these cost estimates only reflect short distance truck transport).[42]

If not located near navigable waterways, ethanol plants ship their ethanol over land to locations from which they can be staged for water shipment. Barges ship this product to the Gulf Coast, usually New Orleans, LA, where it is consolidated and staged for shipment to the East Coast via ocean-going barge or the West Coast via ship (through the Panama Canal).[43] Economics are similar for water and rail shipment of ethanol. The main benefit of marine cargo transport is the large volume capacity and ease of unloading at the destination, when compared to the time required for spotting and unloading multiple rail cars.

From the upper Midwest, ethanol plants fill rail tanker cars on-site. These cars are then transported via spur lines to central rail terminals, called an "origination unit" where ethanol is consolidated. When sufficient volume has accumulated a 100-tank car train of ethanol, called a "virtual pipeline" or "unit train" transports this ethanol to destination terminals on either the East or West Coast. The ethanol is then checked for material consistency and offloaded for either storage, transport to other terminals or blending with gasoline and brought to retail markets.

Ethanol must be protected from water and oxygen contamination during transport. The addition of water or humidity during shipping will contaminate the ethanol and render it useless; therefore, much care is taken during ethanol shipment to prevent any product contamination. Plant employees test ethanol prior to shipping it from the facility, and attach a material safety data sheet (MSDS) to the shipment. Upon arrival at the destination terminal, the ethanol shipment is again chemically analyzed and the results are compared to the data provided from the plant to ensure that the product has not been contaminated. Any shipment found to be out of specification is rejected and either returned to the originating ethanol plant or stored at the terminal for disposal. Because of the high solvency characteristics of ethanol, corrosion

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[42] "The Current Fuel Ethanol Industry Transportation, Marketing, Distribution, and Technical Considerations", Downstream Alternatives, Inc., Robert E. Reynolds, May 15, 2000.
[43] "The Current Fuel Ethanol Industry Transportation, Marketing, Distribution, and Technical Considerations", Downstream Alternatives, Inc., Robert E. Reynolds, May 15, 2000.

inhibitors are added to ethanol at the plant to prevent the ethanol from corroding shipping vessels and becoming contaminated with any residues from these vessels during transport.

Biodiesel transport - Biodiesel is primarily shipped from the plant to the bulk fuel terminals in transport vessels including rail cars, tank trucks, and drums. Biodiesel is not currently shipped via pipeline. As with ethanol, the economics are not currently profitable for pipeline companies to carry biodiesel due to those small volumes that could currently be shipped through pipelines. Biodiesel blends will not separate when exposed to water, but water will increase the chance of biological growth in the fuel. The chance of biological growth can be minimized with the use of biocides.

Biofuels blending - Biofuels are blended with traditional petrochemical fuels at refined product terminals and delivered directly to retail. This minimizes the chance of moisture contamination and phase separation of the gasoline/ethanol blend, and minimizes the terminal's storage requirements (usually only unblended biofuels are stored at the terminal) for biofuels. Biofuels are added to the transport tanker at the point of departure and blended at pre-determined volumes with traditional petrochemical fuels depending on the retailer's specification. Transport trucks are identified through magnetically striped cards by carrier and end customer to ensure that the proper volume of each fuel type and additive is dispensed into the truck. The fuel is dispended and the trucking company then transports the blended fuel to the retail fuel outlet.

Projected Future of Transport

Current biorefining finished product volumes are small enough that barge, rail, and truck shipments are economical solutions. The future view of a biofuels industry producing 60 BGY will require improved economics for transporting finished product to market.

Product exchanges - In the future, many biofuels plants may be distributed throughout rural America. Product exchanges, common to the petroleum industry, may allow biofuels companies to market products in areas that are not otherwise economical to enter. Land-locked biofuels plants would be able to offer their products in distant coastal markets with decreased transportation costs. Plants with waterway access would be able to direct more of their production to coastal markets and still provide product to inland markets through product exchange, also with reduced transportation cost. Overall, the whole ethanol industry would benefit from greater market access and reduced transportation cost. The consumer would benefit as well, seeing lower fuel costs as a result of decreased fuel transportation costs and increased competition within the marketplace.

Biofuels pipelines - To meet large-scale biofuels development, it is likely that new three- to five-inch diameter pipelines will need to be constructed connecting rurally dispersed biofuels plants and central biofuels terminals. Finished product would be shipped through a local network of dedicated biofuels pipelines to a central biofuels terminal, where it would be stored and consolidated. Once a sufficient quantity of biofuel (ethanol or biodiesel) is accumulated, the fuel terminal would ship this biofuel through larger nationwide dedicated biofuels pipelines throughout the United States to regional suppliers (or through existing petrochemical pipelines modified to accept biofuels), where it would be blended with petroleum fuels and trucked to retail.

Constraints to Achieving Future Growth of Transport

Ethanol characteristics - Ethanol is corrosive to some soft metals and certain rubber lines, which must be changed to accommodate this fuel. Additionally, contamination from water normally present in gasoline storage vessels causes phase separation, which renders ethanol fuel blends unusable. Water which is normally present in existing gasoline storage tanks must be removed prior to vessel use for storage of ethanol.

Biodiesel characteristics - Biodiesel is a mild solvent, possessing higher solvency properties than diesel fuel. Blends of 20% biodiesel in petrochemical diesel fuel (B20) have only a minimal increase in solvency, but straight biodiesel (B100) can cause issues (e.g. contamination can occur from residual sediments solvated from deposits from traditional distillate fuel). This situation can cause issues for both storage vessels and vehicle fuel systems that are switched from diesel to B100. For this reason, tanks originally storing diesel must be cleaned prior to being used to store biodiesel fuel. Biodiesel also has a tendency to become unstable during long term-storage, forming gums and sediments. For this reason, biodiesel should not be stored longer than six months without the ability to test the acid number and viscosity.

Current rail constraints – Current rail spur lines are becoming overburdened with current shipments of freight and fuel. Additionally, construction of rail tank-cars is back-logged 18 months. The current U.S. rail infrastructure is incapable of shipping 60 BGY of biofuels.

Need to modify retail infrastructure - Retail distributors include both extensions of major oil and gas companies as well as independent gasoline retailers. Retail distribution of biofuels will require additional costs for modification of and possibly additions to the storage tanks and pumps to offer biofuels to the consumer, possibly costing in excess of $100,000. Small independents may have difficulty justifying such costs, particularly during the early transition period.

Need to improve retail availability - Nationwide, the current availability of biofuels for consumer purchase is quite limited, due to a lack of retail outlets offering biofuels. Biofuels need to be readily available for consumer purchase nationwide at a majority of fuel retailers. At the time of this report, less than one percent of retail outlets nationally offer either E85 or biodiesel blends (1084[44] retail outlets nationally offer E85 and 1076[45] outlets offer biodiesel blends of the almost 170,000 national retail fuel outlets). In fact, little more than one percent of fuel ethanol is blended as E85, while the rest is blended as E10 (a blend of 10% ethanol and 90% gasoline).[46]

[44] National Ethanol Vehicle Coalition (www.e85fuel.com)
[45] National Biodiesel Board (www.biodiesel.org)
[46] "The Ethanol Myth", Consumer Reports (www.consumerreports.org)

Policy Options to Overcome Constraints upon Transport

Government-funded research projects should be conducted to determine the siting requirements for additional biofuels consolidation and shipping terminals necessary to support the rapid expansion of the biofuels industry.

As new biofuels plants are built in more remote areas closer to new feedstock sources, the biofuels produced will need to be stored and consolidated prior to being shipped to the blending terminal. Determining these storage locations in advance of plant construction could help to minimize interconnection difficulties which could arise as the biofuels industry expands.

Research should be conducted to determine the limits of the current biofuels transportation infrastructure and recommend new approaches.

Government-funded research should determine the possibilities and limitations to expanding the barge and rail transportation infrastructure. Congestion along these infrastructure modes is a foreseeable future constraint that must be addressed overcome prior to its eventuality. By anticipating infrastructure loading the industry can determine the breakpoints and take actions to develop alternative modes of shipping (i.e., most likely dedicated pipelines). This research could help enhance infrastructure planning and increase the capacity for nationwide biofuels transport prior to reaching bottlenecks that threaten industry expansion and even sustainability.

The government should research the "least cost" strategy for handling the transition to a 60 BGY future.

The government needs to determine what role it will play to help shape this future. Simulation models could be created to study a scenario where the development of E85 fuel markets would be concentrated near ethanol production facilities to investigate the benefits of minimizing new infrastructure costs and capture potential economies of scale as a least-cost strategy for developing a regional biofuels distribution network.

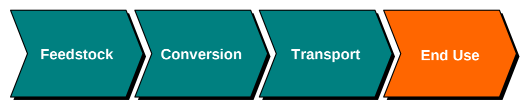
There will likely be a need for a government-sponsored logistics study on mechanisms to fund and construct the expansion of the pipeline infrastructure.

Research should be conducted to determine how the favorable economics present in shipping petrochemical fuels through pipelines can be applied to the biofuels industry. Research could be funded to determine if it is possible, safe, and economical to convert existing multi-products petrochemical pipelines to accommodate shipment of neat biofuels, and what role the government might play to help facilitate this conversion. If this possibility exists, a public/private consortium should be established to consider and address the large-scale capital needs required to integrate biofuels into the existing petrochemical pipeline infrastructure. This coalition should commission rite-of-way and environmental impact studies to determine the environmentally-sensitive options to construct new dedicated biofuels pipelines that connect biofuels plants to central biofuels consolidation terminals. In addition, these studies should consider the possibility of larger, dedicated biofuels pipelines nationwide to transport biofuels to regional suppliers.

There will likely be need for government-funded research on the siting of additional storage and blending terminals.

Further study should be undertaken to determine the regulatory hurdles to siting biofuels infrastructure, so that the biofuels industry is not constrained by regulations and the 'not-in-my-backyard' syndrome that has constrained petroleum refining in the United States. Strategic locations will need to be determined based on regional demand, permitting requirements, and societal impact. This research should be conducted concurrently with transportation and production research to ensure a seamless transition to an effective biofuels storage, transportation, and distribution infrastructure that best serves the rapid expansion of the biofuels industry.

End Use



Americans consume 140 billion gallons of gasoline annually, and this consumption rises at a rate of about 1.5% annually. Despite insignificant retail availability of E85, there are currently over five million flex fuel vehicles (FFVs) on the road today, and U.S. auto manufacturers plan to sell more than one million new FFVs this year. The United States has requirements for vehicle fleets to achieve a set corporate average fuel economy (CAFE) mileage rating. However, neither biodiesel nor ethanol fuels contain the same energy content as conventional petroleum-based fuels.

Fuel economy - Neither biodiesel nor ethanol fuels contain the same energy content as conventional petroleum-based fuels. Straight biodiesel (B100) contains 87% of the energy content of diesel fuel. When biodiesel is mixed at 20% concentration in diesel fuel (B20), the resulting loss in fuel energy is less than 2.5%; this energy impact is negligible to the consumer. Pure ethanol contains only 64% of the energy present in gasoline. When ethanol is mixed at 85% concentration in gasoline (E85), the resulting reduction in fuel energy is 30%. Even with its higher octane number, E85 will cause a noticeable reduction in vehicle fuel efficiency of current FFVs (with engines optimized for gasoline) and result in more frequent trips to the filling station for consumers. Consumer Reports testing showed a loss of fuel economy of 27% for a 2007 Chevy Tahoe FFV when running on E85 as compared to gasoline.[47]

[47] "The Ethanol Myth", Consumer Reports (www.consumerreports.org)

Projected Future of End Use

Increased fuel efficiency of vehicles in general - Biofuels could best meet the national goal of eliminating American dependence on Middle East oil imports if such an initiative were also tied to improved vehicle efficiency. Reduced vehicle weight, such as BMW's planned use of graphite composite materials, as well as expanded use of hybrids and plug-in hybrids can cut the rate of increase in fuel consumption substantially. Whereas conventional cars have an average fuel economy of 30 miles per gallon and hybrids like the Toyota Prius extend that range to about 50 miles per gallon, plug-in hybrid electric vehicles (PHEV) would have the ability to get an equivalent of between 80 to 160 miles per gallon.[48] If the entire U.S. vehicle fleet was replaced by PHEVs, oil consumption would be slashed by over 70% and the need for all petroleum imports would be eliminated. Additionally, the possibility exists to use PHEVs to supplement the electric grid during peak demand periods while increasing the overall efficiency of power production by drawing electricity during off-peak demand periods (i.e., for vehicle charging, mainly at night).

Improved fuel efficiency of E85 vehicles - General Motors recently produced a new SAAB model which demonstrates the ability to offset a portion of the fuel economy reduction inherent to the lower energy content of E85.[49] Through a combination of variable valve and ignition timing, turbo-charging and fuel sensing, this vehicle's engine is able to take advantage of the higher octane present in ethanol. The result is a 30 horsepower increase when using E85 as compared to traditional gasoline, and a reduction in the fuel efficiency loss of E85 by 33%. Unfortunately this vehicle is not available for sale in the United States.

However, optimizing a vehicle's engine for E85 and thus reducing the fuel economy lost in the transition from gasoline to E85 is significant. In terms of miles per dollar, every gallon of E85 delivers on the order of 30% less distance. An additional obstacle is range. Even with an optimized vehicle like the SAAB, the miles traveled per tank will be reduced by 20% when using E85, requiring more frequent stops for refueling.

Constraints upon Future Growth of End Use

Ethanol performance - It is not possible to overcome the lower fuel density of ethanol completely. Future FFVs optimized for E85 will still see a reduction in fuel efficiency (when using E85) of 20% when compared to their fuel efficiency on gasoline (E10).

Consumer awareness - Due to the lack of retail availability of biofuels, very few potential consumers are aware of the benefits that biofuels can provide to the U.S. economy in terms of increased competitiveness, improved national security, sustainable environmental protection, and reinvigorated rural communities. Consumer education will need to be coupled with nationwide availability in order to promote the demand for biofuels necessary to drive infrastructure development and meet our biofuels vision of 60 billion gallons per year. With a useful vehicle life of 12 years, most of the FFVs sold today would help support ethanol's transition from E10 to E85 by increasing future E85 demand.

[48] "Plugging Hybrids", Scientific American, D.M.K., September 2006.
[49] Jones, C. Coleman, Ph.D. – Biofuel Implementation Manager, General Motors Corporation.

Product availability - Low product availability causes higher prices when regional areas are competing for ethanol to satisfy state-mandated fuel oxygenate and air quality emissions regulatory requirements. Ethanol is used in 30% of the current transportation gasoline in the U.S. as either a fuel oxygenate or volume extender, blended as E10. The main incentive for blending E10 is likely to be the VEETC given to fuel blenders when they add ethanol to transportation fuels. This tax credit was intended to be passed along to the consumer as an incentive to purchase biofuels. However, the main effect seems to be increased economics to the fuel blenders. The consumer does not have an option to buy regular gasoline or E10 at the pump (E10 is the only fuel option available in locations that require its use), and the availability of E85 is very limited.

CAFE credits do not incentivize as intended - Current CAFE credits for FFVs assume that the vehicle will run on E85 50% of the time. Taking into account that 50% use of E85 only constitutes 15% gasoline, the FFV CAFE credit provides about a 1.66 multiplier against a vehicle's fuel economy rating for gasoline. This increase is significant in the fuel economy rating for a vehicle that might never use E85 fuel. The 2007 Chevy Tahoe, for example, has a CAFE fuel efficiency rating for gasoline of 21 miles per gallon. The CAFE rating for the same vehicle, when certified as an FFV, jumps to 35 miles per gallon. The maximum that the FFV credit can raise an auto manufacturer's fleet fuel economy is 1.2 miles per gallon. Some observers have been concerned that this incentive could be used by U.S. auto manufacturers to circumvent recent CAFE increases for light trucks and sport utility vehicles (SUVs).

Tax provisions undermine FFV incentives - In addition, tax provisions in the current U.S. code distort the incentives to purchase fuel efficient vehicles. In particular, a 1997 provision in the U.S. tax code (Section 179) provides small businesses with a tax write-off of up to $25,000 for a vehicle weighing more than 6,000 pounds (if it is used 50% of the time for work purposes). While the intent of the law was to encourage small business owners to invest in service vehicles, the provision has actually provided significant rewards to SUV owners purchasing vehicles weighing over 6,000 pounds. This tax provision has been revised several times over the past few years; however, it still provides large incentives for individuals to purchase inefficient vehicles.

Non-importation of desirable vehicles - Regulatory and other constraints prevent importation of vehicles already in production, which offer superior efficiency and E85 optimization. Automobile manufacturers are producing these vehicles for widespread sale and use in other countries, but find the combination of U.S. certification and environmental requirements sufficiently onerous, and the perceived market size as sufficiently limited, that they simply forego introducing these vehicles into the U.S. market.

Policy Options to Overcome Constraints on Growth of End Use

Government could support a reduced cost of E85, until other solutions emerge to address the performance differential.

With current FFVs, every gallon of E85 delivers on the order of 30% less distance. This fuel economy reduction must be offset in some way to keep E85 competitive with gasoline on a miles per dollar equivalent. Reducing the loss in fuel economy allows E85 to be more competitive with gasoline at a higher price. If all other factors are equal, the range issue is the least significant and would most likely be accepted by the average consumer.

Government could create a national corridor of biofuels refueling stations to increase availability and encourage purchase of both E85 and biodiesel.

Increased biofuels availability at a reduced price would drive consumer demand for biofuels and support continued biofuels industry expansion. A biofuels corridor would facilitate interstate travel on biofuels and promote national use.

Government could develop an export market for U.S. ethanol to support continued ethanol industry expansion through a possible slow transition to E85.

A situation may arise during the transition to E85 where ethanol supply exceeds national fuel demand. Anticipating this constraint and averting it with ethanol exports would support continued expansion of the ethanol industry while national demand ramped up to meet the additional ethanol supply.

Government could study the business decisions which cause automakers to forgo introducing FFVs into the U.S. market, and develop a policy response which prompts importation of those vehicles in significant numbers.

In addition to meeting with automakers to understand their perception of the obstacles, government could undertake a significant effort to understand the policies in place in other nations which support widespread consumer adoption of FFVs. This effort may cast light upon the current U.S. regulatory structure as a whole – which was designed for environmental concerns as perceived in the past – and make possible refining the system in light of emerging needs.

A government-sponsored nationwide public education program could encourage the demand for biofuels and FFVs.

Targeted marketing of consumers who are environmentally conscious (stressing decreased carbon impacts), performance-oriented (stressing higher octane), focused on national security (stressing reduced U.S. dependence on imported oil) or interested in supporting rural America (stressing the huge economic boost biofuels provide to rural economies) could go a long way to spark increased demand for biofuels as well as increased purchase of FFVs. Large numbers of

E85 refueling stations exist in the Midwest in close proximity to the rural areas that produce the ethanol. This high concentration of E85 stations is likely due to consumer demand driven by the desire to support the biofuels industry that is helping to revitalize the rural economy of America.

The government should commission a study to evaluate the regulatory and infrastructure changes implemented, and the consumer education programs initiated during the phase-out of leaded gas.

The United States' transition from leaded to unleaded gas in the early 1970s contains many parallels to today's dilemma of switching to the use of biofuels for transportation. Infrastructure requirements, vehicle hardware changes, and consumer education were all requirements supporting the leaded to unleaded transition. This study could determine which of these initiatives were most effective in supporting the transition, as well as which may have been less than effective in encouraging change.

Work closely with auto manufacturers to establish incentives to increase production of FFVs as well as production of FFVs optimized to run on biofuels to help close the fuel economy gap and increase consumer choice of FFVs.

It is not possible to overcome the lower fuel density of ethanol completely. However, optimizing an FFV's engine for E85 can decrease the loss in fuel economy experienced by FFVs fueled with E85 by as much as 33%. Increasing fuel efficiency plays a key role in reducing U.S. dependence on foreign oil imports. Funding joint research programs with auto manufacturers and government could have significant impact on increasing fuel economy. Raising the CAFE standard and increasing the requirement for FFV production would encourage auto manufacturers to focus on efficiency through weight reduction and increased fuel economy. The government could also modify CAFE standards to encourage additional manufacture of FFVs by extending the credit and possibly adding some type of new incentive directed towards the production of FFVs optimized for E85.

A future carbon tax could serve the purpose of leveling the playing field for biofuels. Increasing the gas tax could raise the funds necessary for vehicle efficiency and biofuels infrastructure research projects.

The justification for this increase would be multi-fold: to level the playing field with the traditional petroleum industry, which has received billions of dollars in various incentives in the last several decades; and to account for the environmental and security externalities that are created through its consumption. In addition, a significant portion of U.S. defense spending is devoted to maintaining peace and open supply lines in oil producing nations. These costs are not included into the price of petroleum, creating a security externality.

The U.S. government also has an opportunity to partner with states and cities to create additional incentives for reducing automobile use and encouraging purchases of fuel efficient vehicles.

> For example, the government could dedicate a certain percentage of parking spaces (increasing over time) on all federal property to FFVs, including hybrids, and work with states and cities to follow suit on their properties. In addition, the President of the United States could expand Executive Order 13150, which allows qualified federal employees to reduce their pre-tax income by up to $100 per month for commuting via public transportation, to include employees that walk or bicycle to work.

IV. NEXT STEPS TO ACHIEVE THE 60 BGY VISION

Realizing the 60 BGY biofuels vision will require a large-scale transformation of the energy, agricultural, transportation, and other economic sectors of the United States. Ensuring the appropriate and successful integration of the elements that make up the biofuels system (e.g., rural residents and storage contractors, biofuels plants, retailers, and auto manufacturers) to provide an effective market operation will require a high degree of coordination between the public and private sectors, as well as the support of states, local constituencies, environmental groups, non-governmental organizations, the research and technological communities, investors, and others.

The government's role will be to coalesce the information and stakeholder buy-in needed to create and implement a workable national approach for achieving the 60 BGY goal, drawing upon a combination of the options provided in this paper, as well as others that will emerge in discussion with stakeholders. Therefore, the government's next steps must be designed to maximize the analysis provided in this document and translate it into policy movement.

USDA should conduct a critical stakeholder meeting with federal and local government as well as industry representatives. This meeting will facilitate discussion of the issues, action items and next steps required for the continued rapid expansion of the biofuels industry. USDA should then prioritize the items discussed and develop a roadmap of critical intervention, obtain stakeholder buy-in across both public and private sectors, and determine policy action and funding required to maximize the expansion of the biofuels industry in the United States.

USDA should then translate meeting results into action and policy movement, and develop a Management Plan to implement the actions according to their priority. Support should be generated across Departments and agencies to coordinate and fund the prioritized actions and Management Plan. Relevant USDA policy actions should be proposed for introduction in the 2007 Farm Bill.

APPENDIX A: REGULATORY, TAX AND PROGRAM ENVIRONMENT

Several important pieces of federal legislation and a myriad of state legislation have been passed in support of the biofuels industry. Specific federal legislation contained in both the Energy Policy Act of 2005 and the Farm Bill promotes renewable fuel technology research and development, as well as support for biofuels production in the forms of grants, credits, and mandates for use. State support can be found in renewable fuels standards (RFS) requiring biofuels use, tax credits and other legislative incentives for siting plants and producing biofuels locally, and fuel oxygenate requirements that favor blending of biofuels into the local fuel supply.

Federal

Energy Policy Act - The Energy Policy Act of 2005 (EPAct of 2005) contains a Renewable Fuels Standard (RFS) mandating a doubling of the transportation renewable fuel volume nationally from 4 billion gallons in 2006 to 7.5 billion gallons in 2012, thus increasing the market size and making investments more attractive. The RFS also specifies that by 2013, 250 million gallons of ethanol must be produced using cellulosic biorefining technology. The EPAct of 2005 also establishes financial incentives (subject to authorization of appropriations by Congress) including:

- The DOE to provide loan guarantees ($250 million) for cellulosic and municipal waste ethanol plants, and $1.05 billion in cellulosic biomass ethanol grants ($250 million in 2006, $400 million in 2007, $400 million in 2008) for facility construction;
- $550 million ($110 million per year for 2005 – 2009) for EPA use to fund projects to convert little-used cellulosic biomass feedstocks into ethanol and other useful co-products; and
- A $36 million DOE program for conversion of sugar cane to ethanol in Hawaii, Florida, Louisiana, and Texas. Additionally, the DOE will create loan guarantees of $250 million for commercial demonstration projects for ethanol derived from sugar cane, biogases, and other sugar cane by-products and $50 million in loan guarantees for the construction of sugarcane to ethanol facilities.

Among the other EPAct of 2005 ethanol production incentives designed to encourage the expansion of biofuel production in America is the Volumetric Ethanol Excise Tax Credit (VEETC). This credit provides a $0.51 tax credit per gallon of ethanol blended into gasoline, recently extended through the end of 2010. There is a similar credit for biodiesel blenders, good through the end of calendar year 2008. It provides a $1.00 per gallon blenders tax credit for each gallon of agri-biodiesel (biodiesel made from virgin agricultural products) added to petroleum diesel to form a biodiesel blend, and a $0.50 per gallon blenders tax credit for each gallon of biodiesel (made from other feedstocks including used cooking oil, tallow, and grease trap waste) added to petroleum diesel to form a biodiesel blend.

The Small Ethanol and Biodiesel Producer Credits allow a $0.10 per gallon production tax credit (taken on the first 15 million gallons of production) for plants with a production capacity of up to

60 MGY. This credit is capped at $1.5 million per year per producer and is good through the end of calendar year 2008.

The Tax Credit for Installation of Alternative Fuel Refueling Infrastructure permits taxpayers to claim a 30% credit for installation (or retrofitting) of a refueling infrastructure (retail gas station), up to $30,000, for dispensing either E85 (85% ethanol blended in gasoline) or B20 (20% biodiesel blended in diesel fuel).

Farm Bill - The farm loan and grant programs provide a source of credit when rural residents are temporarily unable to obtain credit from commercial sources. For direct loans, the borrowing limit is $200,000 for any combination of direct farm ownership or operating loans. For guaranteed loans, the borrowing limit adjusts annually for inflation; in 2006 the loan limit is $852,000 for any combination of guaranteed farm ownership or operating loans. The 2007 request is $644 million for direct loans and about $1.3 billion for guaranteed loans.

Section 9006 and the Business and Industry Program provide both loan guarantees and grants. Each year, the unused loan guarantee funding is provided as grants which provide up to $500,000 for renewable energy projects and up to $250,000 for energy efficiency projects, whereas the loan guarantees can be used for projects up to $10 million through section 9006 and up to $25 million through the Business and Industry (B&I) program. The program has used $87.3 million to fund grants and only $34.3 million to provide backing for loan guarantees to 844 applicants since it began in 2003. Grants can be used to pay up to 25% of the eligible project costs, and awards are made on a competitive basis.

During its first three years, Section 9006 invested $61.8 million, leveraging more than $833.7 million according to USDA figures. These projects are estimated to have resulted in the production of 170 million gallons of ethanol and biodiesel fuel production and 300+ megawatts of wind power. The ability to use public funds to leverage private investment through loan guarantees is arguably one of the most powerful government policy levers, yet loan guarantee funds have not been fully utilized. The reasons for this gap may include lack of awareness among rural lenders or other process challenges.

The USDA's Commodity Credit Corporation (CCC) provides funding for commodity programs. Projected outlays are derived from averages to reflect a range of price outcomes and take into account price variability. This ensures that program payments increase when prices fall below specified levels. The commodity programs are mandated by provisions of the Farm Bill. The programs include direct payments to producers of feed grains, wheat, upland cotton, rice, soybeans, other oilseeds, and peanuts. The direct payments, based on historical program acreage and yields, are set by law and do not vary with market prices or current plantings.

Since 2000, legislation in the Farm Bill has provided over $1.3 billion in direct and counter-cyclical payments to landowners who do not actually farm.[50] These federal farm programs started during the Great Depression, providing price guarantees through crop purchase plans in return for limited farm production. In 1973, rural residents were required to limit production to

[50] Washington Post compilation of USDA data, The Washington Post, Sarah Cohen, Laura Stanton, Vaughn Kelso, July 2, 2006.

take advantage of cash payments. In 1996, crop size was not regulated at all; rural residents could plant as much as they wanted of any crop they wished or nothing at all, and still receive payments based on historical plantings, as long as the land did not undergo residential or commercial development.[51] In 2005, the federal government paid $25 billion in rural resident aid, while pre-tax rural resident profits were $72 billion.[52] These subsidy payments have been a source of contention for the World Trade Organization, which believes that some subsidies could affect world price and production of certain agricultural commodities.

State

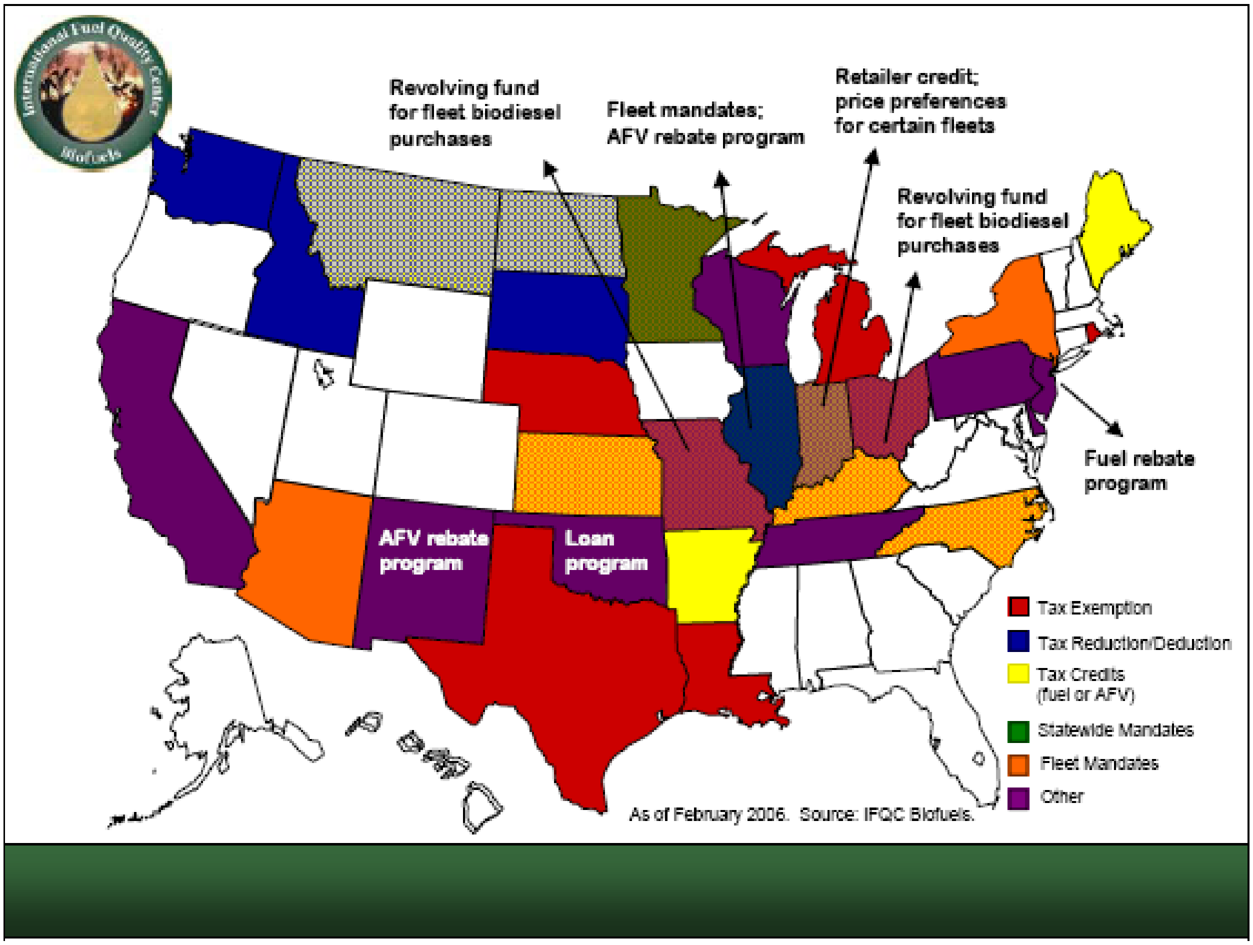
Approximately 31 states provide either user or producer incentives for biofuels, some of which are highlighted in Figure 3. Illinois and Minnesota, for example, have mandated the use of 2% biodiesel blends (B2) in all diesel fuel sold in their respective states subject to certain conditions that include sufficient annual production capacity (defined as at least 8 million gallons). The B2 mandate took effect in Minnesota in September 2005 and in Illinois in July 2006. Several states provide both types of incentives, including Pennsylvania, North Carolina, Illinois, Indiana, Texas, North Dakota and Minnesota.

Many states have enacted legislation supporting the use of biofuels. Hawaii is highlighted due to its lack of a developed infrastructure for biofuel production. In order for the State to meet its RFS target, all Hawaiian fuel ethanol is currently imported. Pennsylvania is highlighted due to the significant economic support it currently provides for the development of biofuels plants and the use of biofuels within the Commonwealth. Pennsylvania should serve as a model for both state and federal policy support of biofuels industry expansion.

Hawaii - Hawaii has taken the first steps toward putting in place a plan for addressing its energy needs. On June 26, 2006, the Governor signed into law comprehensive legislation designed to encourage the development of reliable, cost-effective, and autonomous energy for the state. This new law complements three previous legislative energy self-sufficiency initiatives. Among other significant elements, this bipartisan legislation encourages broader use of renewable energy sources by increasing the renewable energy tax credits. The law also provides Hawaiian support for an alternative fuels standard. Among the renewable energy sources of interest are biofuels. An emphasis on biofuels leverages another unique advantage in Hawaii — the State's significant agricultural assets which can, over time and in combination with wind, solar and other renewables, minimize the need for expensive petroleum imports.

[51] Washington Post analysis, The Washington Post, Sarah Cohen, Dan Morgan, Laura Stanton, July 2, 2006.
[52] "Farm Bill Pays $1.3 billion to People Who Don't Farm", The Washington Post, Dean Morgan, Gilbert M. Gaul, Sarah Cohen, July 2, 2006.

Figure 3 – State incentives for biofuels



Source: Compiled by the IFQC Biofuels Center, February 2006.

Hawaii has established a Statewide Alternative Fuels Standard to encourage the expanded production and use of Hawaiian biofuels. Included in this standard are a number of producer and consumer incentives. The Alternative Fuels Standard requires a 10% substitution of transportation fuel with alternative fuels by 2010, increasing to 15% by 2015, and 20% by 2020. The standard will help drive the opportunity to achieve energy self-sufficiency for Hawaii. However, meeting this standard requires a significant expansion of Hawaii's existing biofuels industry. This biofuels industry expansion must be based on a strong strategic business plan that mitigates against biofuel components becoming more costly to produce biofuel components locally than to import from elsewhere.

To achieve this expansion requires an ambitious plan for collaboration between State and local Hawaiian governments and the private sector. To support this expansion, Hawaii is offering investment tax credits of up to 30% for ethanol manufacturers, capped at $150,000 for low volume producers (500,000 to 1,000,000 gallons per year) rising to $4.5 million for ethanol plants that produce over 15 MGY. This credit is for eight years, with new claims allowed until the statewide ethanol production capacity meets the goal of 40 MGY. Finally, as an incentive to fuel distributors, all sales of ethanol-blended gasoline through the end of calendar year 2006 are exempt from Hawaii's general excise tax. The Hawaiian "Ethanol Content in Gasoline" law took effect on April 2, 2006. This law requires that at least 85% of the gasoline delivered to retail gas stations in Hawaii contain 10% ethanol. Hawaii is currently importing 100% of the ethanol necessary to meet this target, as there is no current local production of ethanol in the state.

Pennsylvania - In Pennsylvania, the Department of Environmental Protection (DEP) is managing the Alternative Fuels Incentive Grant Program to finance production and use of clean-burning fuels within the state. The Governor developed the "PennSecurity Fuels Initiative" to produce and use 900 MGY of clean-burning domestically produced transportation fuel – equal to what the state expects to import from the Persian Gulf in 2016.

As highlighted by the DEP Secretary "To achieve energy security, we must invest in the infrastructure to produce and distribute alternative fuels. As we build the sources and markets for alternative fuels, we will create jobs in Pennsylvania, promote our agricultural communities and clean the air we breathe at the same time." Pennsylvania is offering 5 cents a gallon to producers of biodiesel and ethanol, up to 12.5 million gallons in a 12-month period. Expanded production capacity to 40 MGY will make Pennsylvania a national leader in biodiesel production volume.

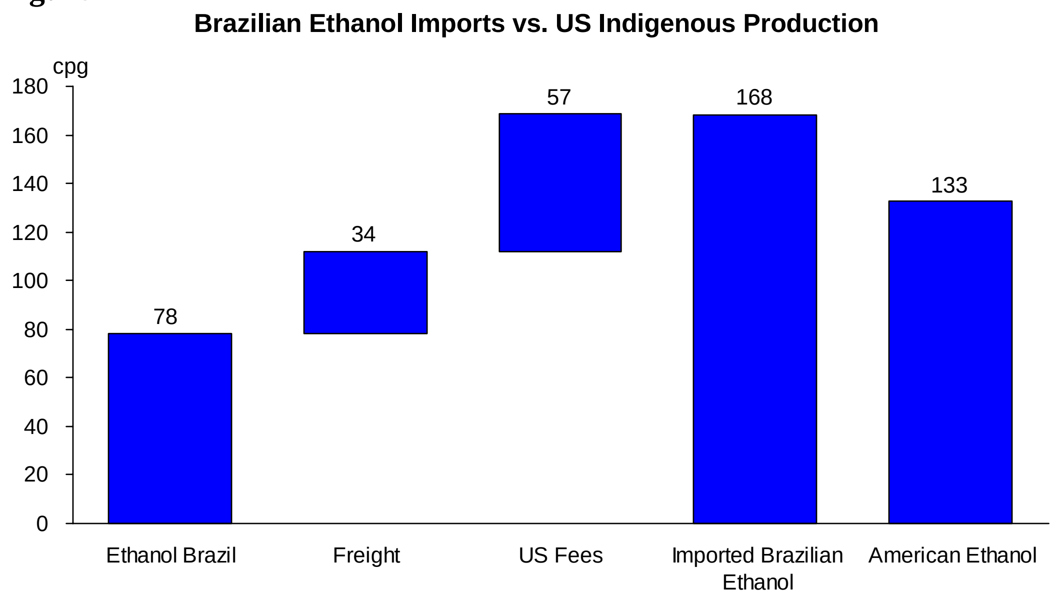
To stimulate the use of biofuels within the state, buy-down grants have been established to cover all additional costs of biofuels use over traditional petrochemical fuel use by school districts, non-profit organizations, transit authorities, and local government agencies.

Announced on August 17, 2006, Clearfield County, Pennsylvania, will soon be home to a 108 MGY ethanol plant. This $250 million dollar project is being built and run by BioEnergy International, LLC, and provides exclusive distribution rights for finished product to Lukoil. The plans are for a $180 million dollar, 108 MGY corn-based ethanol plant, coupled with a $70 million pilot-scale cellulosic ethanol plant, which will use locally available organic waste feedstocks including wood and agricultural residue. Funding is bolstered by $17.4 million in Commonwealth investment. These investments include a $400,000 grant from the opportunity Grant Program, $500,000 in Job Creation Tax Credits (3/5 for the corn plant, 2/5 for the cellulosic), $1.25 million each for a loan and grant through the Infrastructure Development Program, and $14 million ($11 million for the grain plant and $3 million for the cellulosic) through the Redevelopment Assistance Capital Program. This project will provide employment for 300 temporary construction workers and 110 new jobs over the next 5 years to run the facilities. According to Governor Edward Rendell, Pennsylvania contains enough cellulosic material to support in excess of 500 MGY of ethanol.

Import Regulations

The U.S. has attempted to curb biofuels imports to promote domestic biofuels production. Specifically, the $0.57 fee per gallon of imported ethanol raises the price of imported Brazilian ethanol 25% above domestically produced ethanol, as shown in Figure 4.

Figure 4



Source: Booz Allen Analysis

Countries with extended growing seasons and low labor costs like Brazil have lower overall production cost for ethanol. The Caribbean Basin Initiative (CBI) is a trade agreement which provides 24 beneficiary countries with duty-free access to the U.S. market for their biofuels. By installing dehydration units in the Caribbean, some companies have circumvented the U.S. ethanol import fee. Although this has been mentioned by some as an area of concern, only seven facilities have been installed, and their current total annual production capacity is 150 MGY. This small volume of ethanol has done little to affect the U.S. ethanol market.

Near-term focus is the development of the American biofuels industry. Preventing market saturation with less expensive imported biofuels through import tariffs encourages local biofuels production within the United States. However, during the transition from a blend market to a gasoline replacement, local demand for ethanol may fluctuate as production increases possibly outpace national demand. The economics of exporting ethanol to foreign markets could enable the U.S. biofuels industry to continue its rapid expansion during this transition period. Ultimately, biofuels need to become global commodities like oil to compete as replacement fuels on a global scale. Only then will biofuels have the ability to replace significant oil volumes in the world market of transportation fuels.

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