Biofuels Initiative

Needs Requirement Document

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Introduction

In his 2006 State of the Union Address, President Bush outlined the *Advanced Energy Initiative (AEI)*. The President's specific goal for biomass is "to foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012, enabling greater use of this alternative fuel to help reduce future U.S. oil consumption."[1] To support this effort, the President's 2007 Budget increases the Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Office of the Biomass Program's (OBP) research funding by 65% to a total of $150 million[1].

In support of the AEI, the OBP has laid the framework for a Biofuels Initiative (BFI) with the following programmatic goals:

- To make cellulosic ethanol cost competitive with gasoline by 2012
- To displace 30% of the 2004 U.S. motor gasoline demand with biofuels by 2030.

As shown in Figure 1, the goals set for the BFI support the strategic priorities for EERE related to biomass and the national goals of the Department of Energy.

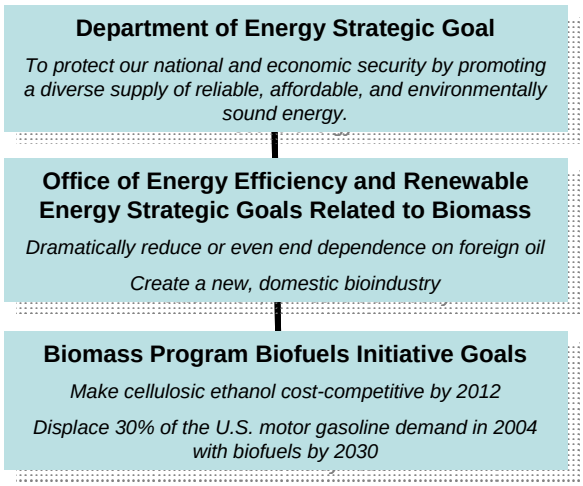


Figure 1. DOE Goal/Organizational Hierarchy

The announcement of the AEI and subsequently, the BFI, has re-emphasized the need to coordinate agencies and programs within the Federal Government to promote the use of biofuels and bring coherence to Federal strategic planning in this area. To this end, OBP has asked the Biomass Research and Development Board, in its role of Federal Agency coordination, to help develop a *Federal Biofuels Posture Plan*. The purpose of the *Posture Plan* is to identify all Federal agencies' activities and roles in support of the BFI.

As the first step toward creating this plan, a workshop is planned for November 28-29, 2006 in Washington, DC. The workshop is being organized through Points-Of-Contact (POCs) from the major biomass research agencies designated by the Biomass R&D Board, which was given statutory authority for Federal biomass strategic planning under the Biomass R&D Act of 2000, as amended by the Energy Policy Act of 2005. The Board is co-chaired by the U.S. Department of Agriculture (USDA) and DOE, and includes members from:

- Department of Interior
- Environmental Protection Agency
- Department of Transportation
- National Science Foundation
- Office of Science and Technology Policy
- Office of the Federal Environmental Executive

[1] Advanced Energy Initiative, The White House, National Economic Council, February 2006 http://www.whitehouse.gov/stateoftheunion/2006/energy

Other agencies (i.e., Department of Defense, Department of Commerce) may also have a role in supporting the BFI and could be asked to contribute to the *Federal Biofuels Posture Plan*.

The OBP and other offices within DOE have held industry stakeholder meetings to gather input regarding the key research, development and technology needs; potential distribution and infrastructure requirements and permitting issues; and policy and deployment drivers that could contribute to achieving the BFI goals. The intent of this document is to capture stakeholder input received to date in order to provide guidance to other Federal agencies in identifying activities that support the BFI. This information, along with input gained from Federal participants at the November 28-29 workshop, will be used to develop a *Federal Biofuels Posture Plan*. This is a dynamic plan that will continue to evolve as Federal roles and requirements are further defined.

Scope of the Biofuels Initiative

Shifting from the established petroleum-based transportation fuel industry to a biofuels-based industry will require large sustainable feedstock supplies, major feedstock and conversion technology advancements, large-scale integrated biorefinery demonstrations, and massive infrastructure development efforts. Policy and other market-based incentives will be needed to stimulate investments in the industry. Permitting issues will also factor into industry growth and will need to be understood and resolved. Education, communication, and outreach programs will be necessary to catalyze the transition on many fronts. The upcoming workshop has been organized to cover the major technical areas of the BFI and the ancillary issues noted above (see inset and Appendix A, *Federal Biofuels Posture Plan* Workshop Agenda).

Federal Biofuels Posture Plan Workshop Breakouts

- *Feedstocks*
- *Biochemical Conversion Technologies (fuels and co-product opportunities)*
- *Thermochemical Conversion Technologies (fuels and co-products opportunities)*
- *Technology Integration, Deployment, and Permitting for Biorefineries*
- *Biofuels Infrastructure (from plant gate to vehicles technologies)*
- *Policy*
- *Communication, Education, and Outreach*

The 2030 market goal is aggressive, calling for more than a ten-fold expansion in biofuels production and use over the next 24 years. Growing the biofuels industry to displace 30% of gasoline demand by 2030 not only implies extraordinary rates of expansion of the existing industry, but also relatively rapid development and market adoption of new technology for converting lignocellulosic biomass into biofuels. The high level timeline to meet the 30X30 goal is shown in Figure 2.

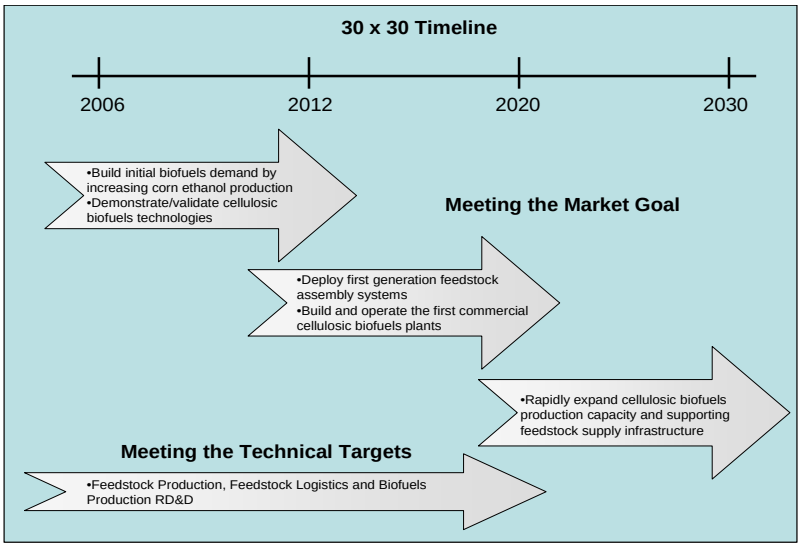


Figure 2. OBP Timeline to 30 X 30 Market Goal

Ethanol was used as a model biofuel in these analyses because it is already well-established as a transportation fuel and is the focus of the 2012 technology goal. In reality, the long-term strategy must remain flexible to other biofuels that may enter the market over time (e.g., biobutanol, hydrogen from biomass). As the feasibility of technology options are examined through RD&D and other avenues (e.g., policy), decisions can be made on which options for producing biofuels are the most likely to succeed and have the largest impact.

The 2030 volumetric goal was based on the "Billion-Ton Study," which was conducted jointly by the DOE and the USDA [2] .The study estimates that the U.S. has the potential to produce up to 1.4 billion tons of biomass annually on a sustainable basis without affecting food, feed, and fiber uses. To put the biomass-to-biofuels potential into perspective, the study estimates that almost 60% of 2004 motor gasoline demands, on a Btu-adjusted basis, could be met with ethanol from grain and biomass, twice the volume defined by the 2030 market goal. The biofuels potential for each type of feedstock evaluated is summarized in Figure 3.

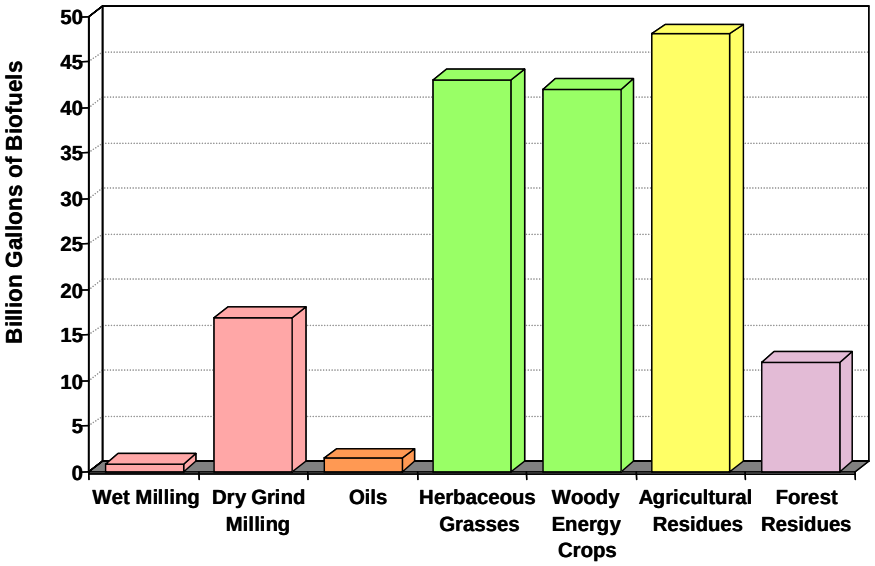


Figure 3. Biofuels Potential by Biomass

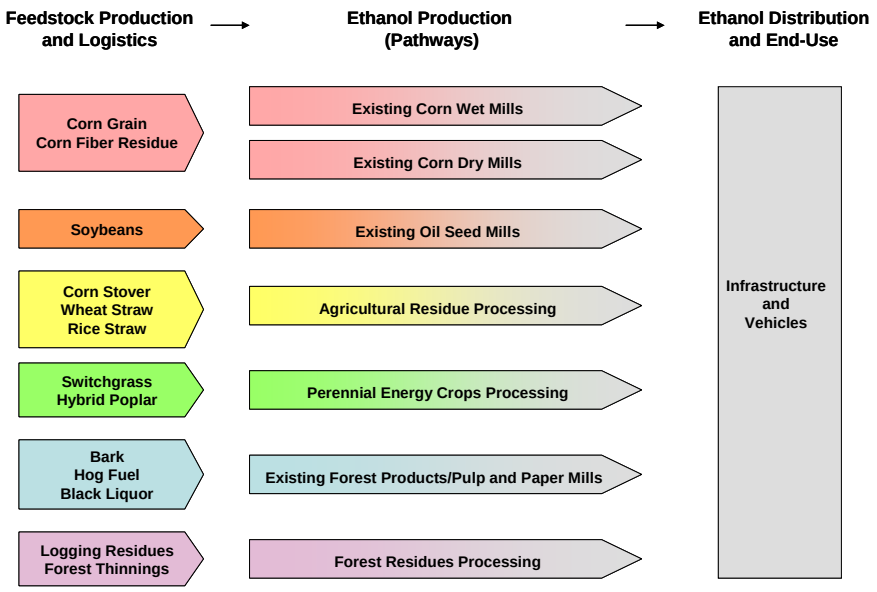
[2] *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. (April 2005). U.S. Department of Energy and U.S. Department of Agriculture. DOE/GO-102005-2135. http://www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

OBP Strategy for Meeting BFI Goals

Over the last 25 years biomass research has been a cornerstone of the Department of Energy's renewable energy development and deployment efforts. The strategic goal of OBP is to develop a new, cost-competitive, sustainable biomass-based energy system for the U.S. through the deployment of integrated biorefineries. These biorefineries will produce fuels, along with products and/or power, from a range of regionally-available biomass feedstocks using a variety of advanced biomass conversion processes. The scope of the *Biofuels Initiative* goes beyond current OBP efforts, which are focused on feedstock production (in cooperation with USDA), feedstock logistics and conversion technologies for biofuels production.

The wide diversity of biomass feedstocks, conversion technologies, integration scenarios, and potential products create opportunities for a multitude of biorefinery options. To help sort out all the possibilities, guide research efforts, and identify the key interfaces that will enable the establishment of commercially-viable integrated biorefineries, OBP has defined seven primary technology pathways. These pathways are linked to the resource base identified in the joint *DOE/USDA Billion Ton Study*, the existing segments of today's bio-industry where possible, and future bio-industry market segments where envisioned. The details of each pathway are described in the OBP Multiyear Program Plan[3]. Each pathway represents a generic set of potential biorefinery scenarios for a specific biomass resource base, as shown in Figure 4. Within each pathway there are multiple viable routes to biofuels production. Pathway schematics are available at http://www.biofuelspostureplan.govtools.us/default.aspx?menu=support).

Figure 4. Biorefinery Pathways Linked to the Resource Base of the Billion Ton Study



Over the next six years, OBP activities will be focused on the near-term BFI goal of making cellulosic ethanol cost-competitive by 2012. The existing bio-industry segments will provide initial leverage points for public-private partnerships to integrate and demonstrate new cellulosic technologies at larger scale in commercial plants where the feedstock is already collected (e.g., corn wet and dry mills, forest products mills). OBP's strategy is to address the near-term pathway needs and then build capabilities in the mid- and longer-term pathways (i.e. agricultural residues, perennial energy crops and forest resources) to a point where biorefineries can produce enough biofuels to meet the 2030 volumetric goal. It is not the intent of DOE to sponsor the development of technology options within all pathways, only the most promising. "Promising" is measured by volumetric potential, economic projections, and stage of technology development to produce biofuels.

Stakeholder Input

Achieving the BFI goals will require the coordinated efforts of a large and diverse group of stakeholders, as illustrated in Figure 5. These stakeholders also provide valuable input and perspective that can be used to identify the critical RD&D challenges and better define the optimum strategic plan for achieving the near- and long-term goals of the BFI.

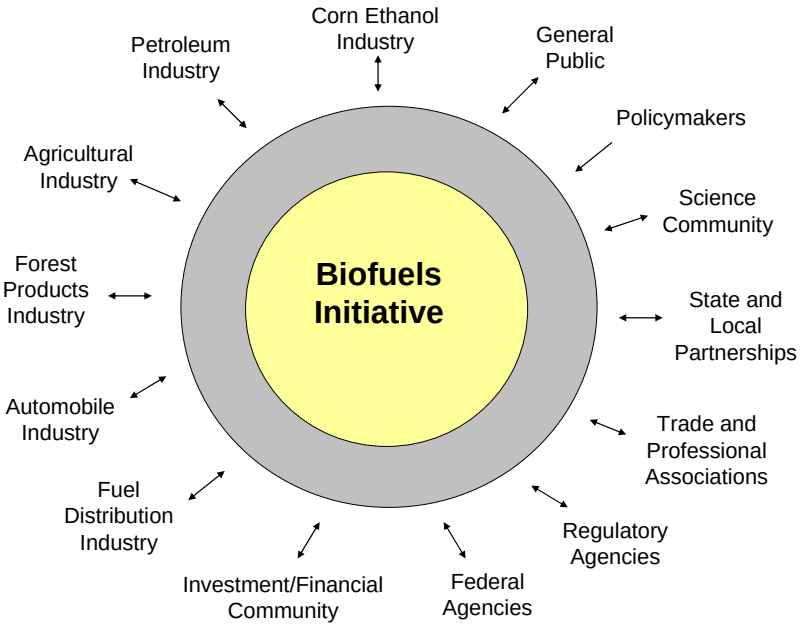


Figure 5. Stakeholders in the Biofuels Initiative

Over the last year, a number of workshops have brought together stakeholders from Federal and State government agencies, industry, universities, trade associations, and environmental organizations to identify the key needs and opportunities for biomass and biofuels in the U.S. These workshops are described below.

- *30 x 30 Industry Workshop* (August 2006) Industry, academic and other external experts in feedstock, conversion technologies, policy, environmental and infrastructure topics were invited to provide independent input regarding key needs to meet the BFI goals.

- *Regional Feedstock Partnership Workshop* (2006) Participants from universities, State organizations, trade associations, DOE and USDA discussed opportunities for collaborative research that will facilitate the development of regional biomass resources.

- *Biomass R&D Technical Advisory Committee Roadmap Meetings* (2006) A series of meetings were held across the country to collect input regarding biomass research and policy needs for consideration in revision of 2002 R&D Roadmap for Biomass Technologies in the United States.

- *DOE's Office of Science Biomass to Biofuels Workshop* (December 2005) This joint DOE Planning Workshop brought together the DOE Offices of Science, Biological & Environmental Research, and EERE, along with EERE's OBP to define how work at the frontiers of science can enable the lignocellulose biorefinery industry and help to identify technology opportunities and barriers.

- *DOE – OBP Deployment Meeting (2005)*

- *DOE – OBP Permitting Meeting (2006)*

The output from these workshops is captured in "Needs Requirement" tables which follow. These tables summarize the RD&D, policy, infrastructure, deployment, education/outreach, and regulatory (especially permitting) needs identified by participating stakeholders to meet the near and longer term goals of the BFI. The information is organized around OBP's biorefinery pathway strategy (Tables 1 through 6) with subcategories in each pathway covering the major technology areas (Feedstocks, Biochemical, Thermochemical, Biorefinery Integration) along with some crosscutting areas. Fuel distribution infrastructure and end use are part of the supply chain for each pathway, and are described separately in a table that applies to all pathways (Table 7). Policy, permitting and regulatory issues, and communication, education and outreach needs also apply to several pathways and are described in separate tables (Tables 8, 9, and 10). The complete list of tables follows:

Table 1: Corn Wet and Dry Grind Mills
Table 2: Agricultural Residues Pathway
Table 3: Herbaceous Energy Crops
Table 4: Short Rotation Energy Crops
Table 5: Forest Products and Resources
Table 6: Natural Oils Utilization Pathway
Table 7: Distribution and End-Use Infrastructure Priorities
Table 8: Policy Needs
Table 9: Education, Communication and Outreach
Table 10: Permitting and Regulatory Needs

The OBP recognizes that the information in these tables does not encompass the *entire* picture of "needs" to meet the BFI goals. It is a first attempt to capture input, organize, summarize, and communicate these needs to all Federal Agencies as a step toward developing the *Federal Biofuels Posture Plan*.

Table 1. Corn Wet and Dry Grind Milling*			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Land Sustainability • Conduct soil, water, water usages and wildlife sustainability studies (includes pest management) Yield and Harvesting • Implement crop densification (i.e. increased harvest and residue yields) using energy and environmental efficient removal practices Feedstock Densification and Material Handling • Explore densification of feeds for storage and transportation purposes • Determine liquid solids properties to identify handling needs and equipment design Demonstration • Evaluate economics of three paths for conversion of fiber to ethanol: (1) process whole, (2) fractionating fiber first, (3) convert to distiller dry grain (DDG) then fractionate	Storage and Transportation • Develop improved moisture content	GMO Feedstocks • Implement breeding technologies to produce cell walls modified for deconstruction to increase carbohydrate yield and other value added trades Transportation and Logistics • Improve efficiency and cost effectiveness of biomass feedstock logistics systems
Biochemical Conversion	Reduce Pretreatment Costs • Increase xylan yields in the corn fiber • Reduce sugar degradation with high solids throughput Reduce Enzyme Production Costs • Understand impacts of pretreatment on enzyme efficacy • Increase saccharification rate	Reduce Pretreatment Costs • Continually increase xylan yields and decrease sugars degradation	Saccharification • Demonstrate new enzymes that easily digest and have high yields of fermentable sugars Hydrolysate Conditioning • Continue reduction of sugar losses in overliming conditioning step Single Step Processing

Table 1. Corn Wet and Dry Grind Milling*			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	Hydrolysate Conditioning • Increase specific activities • Reduce product inhibition • Achieve reduction of sugar losses in conditioning step • Understand effect of conditioning step on fermentation Fermentation • Development of improved ethanologen to co-ferment all biomass sugars to ethanol High Value Co-products • Produce high value chemical and material co-products from biomass sugars • Produce new products from corn DDGs and soymeals derived oils		• Develop commercial organisms for single-step processing that produces competitive ethanol yields
Thermochemical Conversion	Lignin Utilization • Produce heat and power from biomass or residues	Lignin Utilization • Identify and verify the best end-use and processing of fiber	
Biorefinery Integration and Demonstration	Pilot Testing • Begin pilot plant trials for facilities processing fiber and grain simultaneously	Pilot Testing • Completed pilot plant trials for facilities processing fiber and grain simultaneously	

*Corn Wet and Dry Grind Millers - The corn wet and dry grind pathways are vibrant commercial technology pathways and do not require additional pathway development. However, efficiency improvements, cellulosic conversion trials, and the inclusion of high-value co-products can be made within these facilities, improving ethanol yield and also making these facilities more economically attractive. The addition of Corn Fiber to Corn Wet and Dry Grind mills will utilize the same basic unit processes with feedstock specific process improvements in pretreatment and enzymatic hydrolysis.

Table 2. Agricultural Residues Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Land Sustainability • Conduct soil, water, water usages and wildlife sustainability studies (includes pest management) Yield and Harvesting • Implement crop densification (i.e. increased harvest and residue yields) using energy and environmental efficient removal practices Feedstock Densification and Material Handling • Explore densification of feeds for storage and transportation purposes • Determine liquid solids properties to identify handling needs and equipment design Regional Inventory • Develop county-level resource list and economic feedstock analysis to expand upon the Billion Ton Study Feedstock Flexibility • Develop the ability to process multiple feedstocks (blending, depot, or elevator) Demonstration • Complete integrated pilot scale trials for dry agricultural residue feedstocks	Storage and Transportation • Develop improved storage (wet and dry) and transport technologies • Improve wet feedstock infrastructure to reduce feedstocks costs Genomics • Understanding plant systems Particle Sizing • Determine optimum size for transportation and processing Pilot • Complete pilot plant trials for facilities processing multiple feedstocks	GMO Feedstocks • Implement breeding technologies to produce cell walls modified for deconstruction to increase carbohydrate yield and other value added trades Transportation and Logistics • Improve efficiency and cost effectiveness of biomass feedstock logistics systems
Biochemical Conversion	Reduce Pretreatment Costs • Increase xylan yields	Reduce Pretreatment Costs • Continually increase xylan	Saccharification • Demonstrate new enzymes

Table 2. Agricultural Residues Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	• Reduce sugar degradation with high solids throughput Hydrolysate Conditioning • Reduce sugar losses in overliming conditioning step • Understand effect of conditioning step on fermentation Reduce Enzyme Production Costs • Understand cellulase interaction at the plant cell wall increase rate and specificity reduce inhibitors Enzymatic Saccharification and Fermentation • Understand lignin redeposition and other process enzyme effects, and reduce process time • Develop ethanologen to co-ferment mixed sugars to ethanol High Value Co-products: • Produce high value chemical and material co-products from biomass sugars	yields and decrease sugars degradation	that easily digest and have high yields of fermentable sugars Hydrolysate Conditioning • Continue reduction of sugar losses in overliming conditioning step Single Step Processing • Develop commercial organisms for single-step processing that produces competitive ethanol yields
Thermochemical Conversion	Gasification • Conduct bench and pilot scale thermochemical conversion studies to improve syngas quality • Produce syngas from biochemical conversion and agricultural residues Gas Clean-up and Conditioning • Achieve continuous tar reforming efficiencies via catalysts; eliminate SMR	Lignin Utilization • Identify and verify the best end-use and processing of lignin Catalytic Fuels Synthesis • Continue improvement to catalyst to achieve higher single pass conversion efficiencies and greater selectivity to ethanol and mixed alcohols	Pyrolysis • Conduct strategic analysis to tie human needs, resource validation, and existing infrastructure

Table 2. Agricultural Residues Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	Catalytic Fuels Synthesis • Develop catalyst to achieve higher single pass conversion efficiencies and greater selectivity to ethanol and mixed alcohols High Value Co-products • Produce high value chemical and material co-products from biomass lignin Integration/Demonstration • Progressively demonstrate (ending at pilot scale in 2012) improved mixed alcohol yields from gasification of lignin rich biorefinery residues		
Crosscutting	Managing Producer Risk • Educate farmers on regionally viable feedstocks, harvesting equipment, storage practices	Best Practices • Improve overall efficiency in facilities (energy, H2O) i.e. balance of plant	Full System Integration • Validate integrated biochemical and thermochemical processes that optimize the conversion of carbon rich streams and lignin rich streams

Table 3. Herbaceous Energy Crop Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Land Sustainability • Conduct soil, water, water usages and wildlife sustainability studies (includes pest management) Yield and Harvesting • Implement crop densification (i.e. increased harvest and residue yields) using energy and environmental efficient removal practices • Develop need-specific harvesting systems for specific crop types Feedstock Densification and Material Handling • Explore densification of feeds for storage and transportation purposes. • Determine liquid solids properties to identify handling needs and equipment design Regional Inventory • Develop county-level resource list and economic feedstock analysis; to expand upon the Billion Ton Study • Conduct regional testing to determine which energy crops are most appropriate in a given area	Storage and Transportation • Develop improved storage (WET AND DRY) and transport technologies • Improve wet feedstock infrastructure to reduce feedstocks costs Genomics • Understanding plant systems. Particle Sizing • Determine optimum size for transportation and processing Demonstration • Complete integrated pilot scale trials for facilities utilizing energy crop feedstocks	GMO Feedstocks • Implement breeding technologies to produce cell walls modified for deconstruction to increase carbohydrate yield and other value added trades • Develop “tool kits” for plant engineering Transportation and Logistics • Improve efficiency and cost effectiveness of biomass feedstock logistics systems Feedstock Flexibility • Develop the ability to process multiple feedstocks. (blending, depot, or elevator)
Biochemical Conversion		Reduce Pretreatment Costs • Increase xylan yields • Reduce sugar degradation with high solids throughput	Reduce Pretreatment Costs • Continually increase xylan yields and decrease sugars degradation

Table 3. Herbaceous Energy Crop Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
		Hydrolysate Conditioning • Reduce sugar losses in overliming conditioning step • Understand effect of conditioning step on fermentation Reduce Enzyme Production Costs • Understand cellulase interaction at the plant cell wall increase rate and specificity reduce inhibitors Enzymatic Saccharification and Fermentation • Understand lignin redeposition and other process enzyme effects, and reduce process time • Develop ethanologen to co-ferment mixed sugars to ethanol High Value Co-products: • Produce high value chemical and material co-products from biomass sugars	Saccharification • Demonstrate new enzymes that easily digest and have high yields of fermentable sugars Hydrolysate Conditioning • Continued reduction of sugar losses in overliming conditioning step
Thermochemical Conversion		Gasification • Bench and pilot scale thermochemical conversion studies to improve syngas quality • Produce syngas from biochemical conversion and agricultural residues Gas Clean-up and Conditioning • Achieve continuous tar reforming efficiencies via catalysts; and eliminate SMR Catalytic Fuels Synthesis • Develop catalyst to achieve higher single pass conversion efficiencies	Catalytic Fuels Synthesis • Continue improvement to catalyst to achieve higher single pass conversion efficiencies and greater selectivity to ethanol and mixed alcohols Lignin Utilization • Identify and verify the best end-use and processing of lignin Selective Thermal Processing

Table 3. Herbaceous Energy Crop Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
		and greater selectivity to ethanol and mixed alcohols <u>Integration/Demonstration</u> • Progressively demonstrate (ending at pilot scale) improved mixed alcohol yields from gasification of lignin rich biorefinery residues <u>High Value Co-products</u>: • Produce high value chemical and material co-products from biomass lignin	• Expand product slate from thermochemical processing o Utilizing Gibbs free energy <u>Pyrolysis</u> • Conduct strategic analysis to tie human needs, resource validation, and existing infrastructure
Crosscutting		<u>Managing Producer Risk</u> • Educating farmers on regionally viable feedstocks, harvesting equipment, storage practices	<u>Best Practices</u> • Improve overall efficiency in facilities (energy, H2O) i.e. balance of plant <u>Full System Integration</u> • Validate integrated biochemical and thermochemical processes that optimize the conversion of carbon rich streams and lignin rich streams

Table 4. Short Rotation Woody Crops			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Regional Inventory • Develop county-level resource list and economic feedstock analysis to expand upon the Billion Ton Study • Model Energy Crops and determine where they best fit SRWC Management • Conduct economic analysis for the producer to begin growing woody crops for energy vs. other uses Collection/Harvesting/ Transportation • Evaluate costs associated with harvesting and transporting the feedstock • Evaluate whole tree vs. terrain cut to length chaparral Storage • Evaluate storage impacts on composition of the feedstock • Evaluate needs for pelletizing feedstocks	Genomics • Increase understanding of woody plant systems • Determine genes responsible for desired trait improvements to ease bioprocessing to higher ethanol yields SRWC Management • Implement planting and use of regionally identified for SRWC Feedstock Flexibility • Develop the ability to process multiple feedstocks. (blending, depot, or elevator)	GMO Feedstocks • Implement breeding technologies to produce cell walls modified for deconstruction to increase carbohydrate yield and other value added traits Demonstration • Complete integrated pilot scale trials for SRWC
Biochemical Conversion		Characterize Feedstock Quality • Evaluate ethanol yields • Optimize pretreatment and enzyme process variations for conversion of SRWC Hydrolysate Conditioning • Reduce sugar losses in conditioning step • Understand effect of conditioning step on fermentation	Reduce Pretreatment Costs • Increase sugar yields • Reduce sugar degradation w/ high solids throughput Demonstration • Complete integrated pilot scale trials for facilities utilizing SRWC feedstocks

Table 4. Short Rotation Woody Crops			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
		Fermentation • Develop ethanologen to co-ferment mixed sugars to ethanol • Evaluate viability of syngas fermentation to ethanol High Value Co-products • Produce high value chemical and material co-products from biomass sugars	
Thermochemical Conversion		Gasification • Document correlations between feedstocks and syngas quality • Produce syngas from spent pulping liquor, wood residues and other process residues • Develop feeder systems for gasification of solid biomass • Optimize forest resource conversions to syngas Gas Clean-up and Conditioning • Achieve continuous tar reforming efficiencies via catalysts; eliminate SMR Catalytic Fuels Synthesis • Develop catalyst to achieve higher single pass conversion efficiencies and greater selectivity to ethanol and mixed alcohols Integration/Demonstration • Progressively demonstrate (ending at pilot scale in 2012) improved mixed alcohol yields from gasification of lignin rich biorefinery residues	Lignin Utilization • Identify and verify the best end-use and processing of lignin ethanol, mixed alcohols or other products from syngas Pyrolysis • Develop gydrotreating and upgrading for green diesel o Improve efficiency of hydrotreating and upgrading pyrolysis oils to biofuels o Improve catalyst stability and robustness o Improve stability of bio-oil intermediate (pyrolysis oils)

Table 5. Forest and Pulp and Paper Mills			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	<u>Sustainability</u> • Study forest sustainability and wildlife habitat impacts from removing thinnings <u>Collection and Transportation</u> • Develop technologies to collect thinnings • Evaluate costs <u>Yield and Harvesting</u> • Implement crop densification (i.e. increased harvest and residue yields) using energy and environmental efficient removal practices • Develop need-specific harvesting systems for specific crop types <u>Feedstock Densification and Material Handling</u> • Explore densification of feeds for storage and transportation purposes • Determine liquid solids properties to identify handling needs and equipment design <u>Regional Inventory</u> • Develop county-level resource list and economic feedstock analysis to expand upon the Billion Ton Study • Conduct regional testing to determine which energy crop are most appropriate in a given area		
Biochemical Conversion	<u>Analysis</u> • Evaluate the ability to bring in new forest feedstocks (thinnings) into existing facilities for separate processing to sugars <u>Sugar Extraction</u> • Conduct study on extracting c5/c6 sugars from hemicellulose (upstream of pulp digester) and	<u>Characterize Feedstock Quality</u> • Evaluate ethanol yields • Optimize pretreatment and enzyme process variations for conversion of forest thinnings and residues	

Table 5. Forest and Pulp and Paper Mills			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	effect on pulp quality <u>Fermentation</u> • Develop ethanologen to co-ferment mixed sugars to ethanol • Evaluate viability of syngas fermentation to ethanol		
Thermochemical Conversion	<u>Gasification</u> • Document correlations between feedstocks and syngas quality • Produce syngas from spent pulping liquor, wood residues and other process residues • Develop feeder systems for gasification of solid biomass • Optimize forest resource conversions to syngas <u>Gas Clean-up and Conditioning</u> • Achieve continuous tar reforming efficiencies via catalysts; eliminate SMR <u>Catalytic Fuels Synthesis</u> • Develop catalyst to achieve higher single pass conversion efficiencies and greater selectivity to ethanol and mixed alcohols <u>Integration/Demonstration</u> • Progressively demonstrate (ending at pilot scale in 2012) improved mixed alcohol yields from gasification of lignin rich biorefinery residues	<u>Lignin Utilization</u> • Identify and verify the best end-use and processing of lignin into ethanol, mixed alcohols or other products from syngas <u>Pyrolysis</u> • Develop hydrotreating and upgrading for green diesel o Improve efficiency of hydrotreating and upgrading of pyrolysis oils to biofuels o Improve catalyst stability and robustness o Improve stability of bio-oil intermediate (pyrolysis oils)	<u>Selective Thermal Processing</u> • Expand product slate from thermo-chemical processing o Utilizing Gibbs free energy <u>Pyrolysis</u> • Conduct strategic analysis to tie human needs, resource validation, and existing infrastructure

Table 6. Natural Oils Utilization Pathway			
Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Genomics • Determine genome sequence for soybeans GMO Feedstock • Improve plant genetics for fuel production (This work will need to begin immediately for long-term implementation) • Reduce recalcitrance of cellulose to ease digestion • Double yield per acre for oilseeds • Conduct R&D to control composition of crops • Improve crop robustness (pest and drought resistance, optimize utilization of fertilizers, nutrients, water, etc)	Genomics • Determine genome sequence for oilseeds Plant Physiology • Understand the plant mechanisms for oil synthesis and accumulation	Feedstock Yield and Production • Develop herbicides, pesticides, and fungicides (for new crops)
Biochemical Conversion – No needs identified			
Thermochemical Conversion			Green Diesel • Study/develop new chemical transformations to make green diesel (carbon-skeletal rearrangements) • Explore routes to process Intensification
Biorefinery Integration and Demonstration	Co-Products • Develop technologies for the extraction and conversion of proteins to alternate fuels and value added products • Develop and demonstrate meal fractionating technologies • Explore use of glycerin as a feedstock for additional value added products	Protein Chemistry • Develop protein based chemistry (transformational chemistry to fuels or chemicals/ materials)	Market Development • Develop markets for oil-extracted DDGs

Table 7. Distribution and End-use Infrastructure Priorities			
Note: (1), (2), etc indicate priorities that repeat throughout the table.			
Infrastructure Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Distribution (plant to terminal/blender – Wholesale Distribution)	• Determine compatibility of biofuels with current material of construction used in existing fuel infrastructure (accelerated Aging) including metals, plastics, rubber, others (1) • Define specifications for universal (100% compatible) materials with current petroleum and biofuels and work towards driving costs down (2) • Investigate increasing throughput of existing rail and barge systems • Investigate back haul potential to eliminate deadheading • Start outlining where additional track will need to be laid (particularly short rail) ---- mapping where biofuels will be produced	• Research ability to use existing pipelines and/or identify need for new biofuels pipelines • Implement use of selected universal material (3) • Determine and balance critical mass of FFVs with supply of biofuels (4) • Expand rail and barge to accommodate larger amount of biofuels in the transportation system	• Develop dedicated transportation network for biobased fuels • Build identified pipelines and/or rail and barge
Terminal infrastructure (blender)	• (1) • (2) • Build storage capacity to accommodate increasing ethanol usage • Evaluate need for capital investment in tanks, pumps, etc	• (3) • (4) • Build storage capacity to accommodate increasing ethanol usage	• Build storage capacity to accommodate increasing ethanol usage
Distribution (blender to fueling station – Retail Distribution)	• (1) • (2) • Evaluate need for capital investment in tanker trucks; may need dedicated spaces for E85	• (3) • (4)	
Fueling Stations (Retail Sales)	• (1) • (2) • Conduct *Multi-modal Transport Study* – A joint public-private study involving government, the fuels and automotive	• (3) • (4) • Facilitate capital investment for new tanks at existing fuel stations (implementing the	• Expand network of E85 fueling stations based on the transport plan

Table 7. Distribution and End-use Infrastructure Priorities			
Note: (1), (2), etc indicate priorities that repeat throughout the table.			
Infrastructure Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	industries, and industries which comprise the supporting infrastructures (i.e., regional, corridor, national, fleets) --- develop Government Plan • Develop materials that allow biofuels to meet EPA standards • Design system to eliminate misfueling issues (for non-E85 vehicles) • Implement consumer education program (E85, FFV, alternative biofuels, etc) – continue through long-term	transport study) • Implement consumer education program	
Vehicle Engine Optimization	• (1) • (2) • Optimize engines for any mixture of petroleum and biofuels o Fuel efficiency, evaporative emissions, pollutant emissions, etc • Implement consumer education program (E85, FFV, etc) – continue through long-term • Implement plan for 85% FFVs in the next 15 yrs	• (3) • (4) • Meet current EPA and PZEV standards • Work with EPA to develop an emissions profile specific to biofuel blends (develop the right catalytic converter, etc)	
Vehicle Fuel Quality (meeting specifications for manufacturers acceptance and warranty)	• Conduct R&D to define test methods quantifying any impurity at very low levels • Review and refine ASTM methods for all biofuels to insure vehicle compatibility • Define and develop international standards for all alternative fuels	• Issue ASTM standards	
Vehicle Production and Deployment	• (2)	• (3) • (4)	• Implement plan that calls for 85% of vehicles manufactured

Table 7. Distribution and End-use Infrastructure Priorities			
Note: (1), (2), etc indicate priorities that repeat throughout the table.			
Infrastructure Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
		• Achieve deployment of optimized E85 vehicles	to be engine optimized (E85) FFVs
Stationary Applications	• Demonstrate and validate applications for direct use of vegetable oils in primarily stationary biodiesel applications (generators, etc)		
Crosscutting	• (1) • Initiate public education/outreach in getting people to use biofuels based on price and performance	• Continue public education/ outreach in getting people to use biofuels based on price and performance	

Table 8. Policy Needs*			
Policy Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstocks	Incentives for regional feedstock development (introduction of new crops to region)		
	Farm policy to effectively manage the stewardship of CRP lands		
Biofuels Production	New RFS (begin to specify amounts of each fuel) focused meeting on meeting the 60 billion gallon goal by 2030.		
	Incentivize lignocellulosic ethanol (on parody w/ other biofuels)	Have technology in place to eliminate the additional lignocellulosic incentive	
Infrastructure - Biofuels Distribution	Maintain blender tax credit and expand credit to all products that displace petroleum (51 cent/gal credit is equivalent to 7.7 cent/lb credit)		
	Amnesty program when installing tank and committing to ethanol ways at the station		
		Incentivize the development of fueling stations based on the Transport Plan	
		Potential policies to drive infrastructure development	
			Accelerated tax write off for capitalization of pipelines
Infrastructure - Biofuels End Use	Provide incentives to improve fuel efficiency, including raise CAFÉ standards and increased use of diesel engines (phasing out CAFÉ credit and provide alternative incentives		
	Consistent policies for fuels mandates/ incentives - federal/state, state/state regional, and regionally. There needs to be a rational framework		
		Sliding scale on tax credit for FFVs that fades away to as you increase your production and near the volumetric goal (include externalities)	
Crosscutting			Implementation of carbon tax and/or credits (petroleum displacement credits)
	Educational outreach to ensure a supply of qualified people for the expanding industry		

Table 8. Policy Needs*			
Policy Area	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
	Guaranteed Oil Floor at $xx/barrel		
		Tax petroleum imports	
	Fully implement EPAct		

* This table captures all the suggested policy options from our stakeholders. These suggestions need to be evaluated to decide which are appropriate to include in the Posture Plan. Future policies should be geared towards reaching the BFI's 60 billion gallon goal over the next 25 years. The final policy recommendations in the Posture Plan need to be fluid and adapt over the coming years to the changing needs of the growing industry. Generally, it is recommended that:

- Policies should be implemented for the production and use of biofuels and bioproducts to ensure a domestic supply of fuels and chemicals to meet U.S. strategic needs.
- Policy should be analyzed to identify and remove duplicative and counter-intuitive measures.

Table 9. Education/Communication/Outreach - General Needs			
Area/Timeframe	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstock Production	Generally educate farmers about switching practices (benefits, availability, management practices, etc)		
	Educate research institute capability to address the various R&D needs (specifically on feedstock side)		
Biofuels Production	Develop manpower to support and staff biorefineries now under development and in the future		
Biofuels Distribution			
Biofuels End Use	Provide consumer education on biofuels characteristics and use		
Crosscutting	Develop a project deployment primer to assist technology developers in overcoming many of the logistical barriers they will encounter throughout the duration of the deployment process		

Table 10. Permitting/Regulatory Issues- General Needs			
Areas/Timeframe	**Near term (0-5 years)**	**Mid term (5-10 years)**	**Long term (10+ years)**
Feedstock -Production	Genetically modified (gm) crops		
	Soil erosion control		
	Conservation reserve program regulations		
	Osha		
Feedstock -Logistics	Land use – Traffic congestion		
	OSHA		
Biofuels Conversion Technologies (Biochemical and Thermochemical)	Land use		
	Water use		
	Water discharge		
	Air emission controls; criteria pollutants, hazardous pollutants, odor		
	OSHA		
	Genetically modified microorganisms		
	Co-products derived from GM crops		
Infrastructure -Biofuels End Use	Vehicle tailpipe and evaporative emissions limits		
	Emissions from stationary biofuels powered systems		
Crosscutting	Establish guidelines that could be shared amongst municipalities for local construction, operations, etc (OSHA, but mostly local controlling authorities)		
	Establish national permitting criteria guidelines regarding: water usage, air quality, water discharge quality, etc. (EPA)		

Conclusion

The tables capturing input from the various stakeholder meetings are being shared with all the Federal Agencies to aide in the development of a comprehensive *Federal Biofuels Posture Plan*. The intent is for the agencies to review the tables to gain an understanding of how activities they may be currently conducting or plan to conduct may support the needs (captured in the tables) to meet the BFI goals.

The information captured in these tables is by no means the entire story. It will have to be updated often to keep up with technology, policy, infrastructure development, and other evolving issues. This would allow for change of direction or "course correction". It is recommended that this document and the *Federal Biofuels Posture Plan* (to be developed) are reviewed annually to make these necessary changes.

As mentioned, the next step is conducting a workshop to develop the *Federal Biofuels Posture Plan* involving agencies with biomass related activities that may support the needs of the BFI. This workshop is scheduled for November 28-29, 2006. For more information on the Federal Biofuels Posture Plan workshop go to http://www.biofuelspostureplan.govtools.us/

Appendix A – Federal Biofuels Posture Plan Workshop Draft Agenda

NOVEMBER 28, 2006

7:30 a.m. – 8:00 a.m.	**Continental Breakfast**	**Location TBD**
8:00 a.m. – 11:30 a.m.	**Opening Plenary Session**	**Location TBD**
8:00 a.m. – 8:30 a.m.	**Welcoming Remarks** Thomas C. Dorr, Under Secretary for Rural Development and Chairman of the USDA Energy Council Alexander "Andy" Karsner, Assistant Secretary for Energy Efficiency and Renewable Energy, DOE	
8:30 a.m. – 8:40 a.m.	**Overview of the Biofuels Initiative (BFI) and how it relates to the President's Advanced Energy Initiative** Douglas Kaempf, DOE-OBP	
8:40 a.m. – 9:00 a.m.	**"Needs Requirements" Document Input Process** • Recent Collaborative Planning Efforts: John Ferrell, DOE-OBP • National Biomass Initiative: Thomas Binder, Biomass R&D Technical Advisory Committee	
9:00 a.m. – 9:10 a.m.	**Announcement: Release of updated *Vision for Bioenergy and Bioproducts in the United States*** Thomas Ewing, Chairman, Biomass R&D Technical Advisory Committee **The *Vision* release will include a ten-minute public question and answer period.**	
9:10 a.m. – 11:15 a.m. morning break: 10:00 a.m. – 10:15 a.m.	**Agency Overview Presentations** – Briefing on agency mission as it relates to the biofuels. (10 min each) Department of Defense – William Bolten Department of Interior – Peter Teensma Department of Agriculture – Douglas Faulkner Department of Commerce – Hratch Semerjian Department of Transportation – William Chernicoff Department of Energy – Neil Rossmeissl Environmental Protection Agency – Michael Catanzaro National Science Foundation – Bruce Hamilton Office of Science and Technology Policy – Kevin Hurst Office of the Federal Environmental Executive – Dana Arnold	
11:15 a.m. – 11:30 a.m.	**Workshop Overview & Outcomes (Scope/Purpose/Goals)** John Ferrell, OBP-DOE	

11:30 a.m. – 12:30 p.m.	**Lunch Break** (on your own)	
12:30 p.m. – 4:30 p.m. afternoon break: 2:30 p.m. – 2:45 p.m.	**Day 1 Breakout Sessions** – Identify current and future agency level activities as they relate to biofuels.	
	1. Feedstocks (resource availability & infrastructure, etc)	**Location TBD**
	2. Biochemical Conversion Technologies (fuels and co-product opportunities)	**Location TBD**
	3. Thermochemical Conversion Technologies (fuels and co-products opportunities)	**Location TBD**
	4. Technology Integration, Deployment, and Permitting for Biorefineries	**Location TBD**
	5. Biofuels Infrastructure (from plant gate to vehicles technologies)	**Location TBD**
	6. Communication, Education, and Outreach	**Location TBD**

NOVEMBER 29, 2006

7:30 a.m. – 8:00 a.m.	**Continental Breakfast**	**Location TBD**
8:00 a.m. – 12:00 p.m. morning break: 10:00 a.m. – 10:15 a.m.	**Day 2 Breakout Sessions (Same as Day 1) –** Begin to frame Posture Plan	**Return to Day 1 breakout rooms**
12:00 p.m. – 1:30 p.m.	**Lunch** (on your own)	
1:30 p.m. – 3:30 p.m.	**Plenary Session –** A representative from each breakout session will present a session summary.	**Location TBD**
3:30 p.m. – 3:45 p.m.	**Closing Remarks** Douglas Kaempf, DOE-OBP	**Location TBD**