VISION

FOR BIOENERGY AND BIOBASED PRODUCTS IN THE UNITED STATES

Bioeconomy for a Sustainable Future

2006

Biomass Research and Development Initiative

Foreword

The ***Vision for Bioenergy and Biobased Products in the United States*** was initially created in 2002 to establish far-reaching goals to increase the role of biobased energy and products in our nation's economy. It represented the collective vision of the Biomass Research and Development Technical Advisory Committee established by the Biomass R&D Act of 2000. This document is an update to that Vision.

The process of updating the Vision began with an appraisal of our nation's progress toward the original Vision goals as mandated by Congress under the U.S. Energy Policy Act of 2005 (P.L. 109-58). A one-day workshop was held in November 2005 where 20 individuals from industry, academia, and government provided their expertise and insight toward updating the Vision (see Appendix A for a list of participants). The workshop participants evaluated progress toward the original goals, and what was needed to achieve these goals. The Vision update was followed by an independent peer review (see Appendix B for a list of participants) and final approval by the Biomass R&D Technical Advisory Committee and Interagency Biomass R&D Board. The long-term goals in the Vision are intentionally aggressive and challenging because the Vision defines what the nation can and should be doing to achieve a biobased economy. In addition, the Committee recommends the U.S. Departments of Agriculture and Energy conduct a longer-term analysis to benchmark current markets for biomass and opportunities under various economic and policy scenarios.

For more information on the Biomass R&D Act of 2000 and the Technical Advisory Committee, visit:
http://www.biomass.govtools.us

Executive Summary

The United States is at a critical point in determining its energy future. One path will lead to continued dependence on fossil fuels for energy needs, the other toward a more balanced and diverse energy portfolio that includes domestic biomass resources. In 2004, fossil fuels supplied 86 percent of U.S. energy needs, with the majority, 40 percent, coming from petroleum.[1] In recent decades, U.S. dependence on imported oil has reached untenable levels. In 2005, about 65 percent of crude oil and petroleum products were supplied by imports, out of which 17 percent came from the Persian Gulf region.[2] Natural gas imports accounted for 20 percent of the total U.S. natural gas consumption in 2005.[3] A continued dependence on oil and gas will increase our vulnerability to price fluctuations as well as increase our reliance on foreign nations to fuel our economy.

> Vision Statement -
> By 2030, a well established, economically viable, bioenergy and biobased products industry will continue new economic opportunities for the United States, protect and enhance our environment, strengthen U.S. energy security, provide economic opportunity, and deliver improved products to consumers.

A more robust portfolio of feedstocks for our nation's energy supply must be found. Biomass resources are sustainable and offer an environmentally friendly feedstock which can contribute significantly to creating this diverse portfolio. Biomass technologies can help reduce global warming, a principal environmental impact of fossil fuel consumption. Achieving this shift from fossil-fuel-based energy supply to bioenergy will infuse dollars back into the domestic economy creating new markets and jobs.

In order to realize this opportunity, the Biomass R&D Technical Advisory Committee established the ***Vision for Bioenergy and Biobased Products in the United States***.[4] It established aggressive goals for biopower, biofuels and biobased products, defining market share targets and consumption for 2010, 2020, and 2030. These targets were set to benchmark the progress toward achieving the 2030 Vision of a "well established, economically viable, bioenergy and biobased products industry." A November 2005 assessment of the current status on the nation's progress toward these targets revealed that in some cases the nation is not on track to meet them. This document updates the 2002 Vision. While recognizing the current shortfalls, it does not change the original 2010 goals but does make minor changes to its 2020 and 2030 goals. Additionally, the document establishes 2015 goals to define interim milestones that must be achieved to reach the aggressive targets set for 2020 and 2030. Updated Vision goals are shown below.

Achieving the Vision will require a blend of research and demonstration, and policy measures, as well as efforts to educate future scientists and engineers on biomass feedstocks and conversion technologies for the biobased economy. A number of common misconceptions have hindered positive public perception of biomass. In order to realize the Vision, it is important to educate the public, decision makers, and others about the real costs associated with using fossil fuels.

Vision Goals

	Units	2000	2004	2010	2015	2020	2030
Biofuels	Market share (%)	0.7	1.2	4.0	6.0	10.0	20.0
	Consumption (billion gasoline-equivalent gallons)	1.1	2.1	8.0	12.9	22.7	51.0
Biopower	Market share (%)	3.0	3.0	4.0	5.5	7.0	7.0
	Consumption (quadrillion Btu)	2.0	2.1	3.1	3.2	3.4	3.8
Bioproducts	Production (billion lbs)	12.8	17.6	23.7	26.4	35.6	55.3

Biomass Research and Development Technical Advisory Committee

2005 Members		2006 Members	
Name	**Organization**	**Name**	**Organization**
J. Wayne Barrier	Metropolitan Energy Systems, Inc.	James Barber	Metabolix, Inc.
Thomas Binder	Archer Daniels Midland	Arthur Blazer	New Mexico State Forestry
Robert Boeding	National Corn Growers Association	Jerrel Branson	Biocrude, LLC
Jerrel Branson	Biocrude, LLC	Ralph P. Cavalieri	Washington State University
William Carlson	Carlson Small Power Consultants	Bob Dinneen	Renewable Fuels Association
Ralph P. Cavalieri	Washington State University	Tom Ewing*	Davis & Harman, LLP
Tom Ewing*	Davis & Harman, LLP	Carolyn Fritz	Allylix Inc.
Carolyn Fritz	Allylix Inc.	Douglas Hawkins	Rohm and Haas Company
Charles Goodman	Southern Company	John Hickman	John Deere
Jack Huttner	Genencor International, Inc.	Jack Huttner	Genencor International, Inc.
F. Terry Jaffoni	Clean Transportation Fuels	F. Terry Jaffoni	Clean Transportation Fuels
Kim Kristoff	GEMTEK Products	Charles Kinoshita	University of Hawaii at Manoa
David Morris	Institute for Local Self Reliance	Eric Larson	Princeton University
Gary Pearl	Fats and Proteins Research Foundation, Inc.	Jim Martin	Omni Tech International, LTD.
Delmar R. Raymond	Weyerhaeuser Company	Scott Mason	Conoco Phillips
Philip L. Shane	Illinois Corn Marketing Board	Larry Pearce	Governors' Ethanol Coalition
		Delmar R. Raymond	Weyerhaeuser Company
		Ed White	SUNY College of Environmental Science and Forestry

* Interim Member

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Introduction: Benefits of Achieving the Vision

Biomass – Any plant or plant-derived material, including animal manure and waste materials, which can be converted into fuels, products, or power through various conversion processes.

The United States has become increasingly dependent on imports to meet its growing petroleum needs. In 2005, over 65 percent of U.S. crude oil and petroleum products were supplied by imports, while natural gas imports accounted for 20 percent of U.S. total natural gas consumption.[5] In recent years, the demand for petroleum and natural gas has been escalating globally as economies of developing countries are growing rapidly, mounting pressure on world energy markets and prices. Crude oil prices have risen sharply, while natural gas prices in all sectors have increased threefold from 1985-2005, exacting high costs for consumers, industry, and nations as a whole.[6] Such volatility in petroleum prices combined with the extensive U.S. reliance on fossil fuels is testing the limits of our nation's economic, environmental, and homeland security.

A more robust portfolio of domestically produced feedstocks for our nation's energy and chemical supply must be found. Biomass resources are sustainable and offer an environmentally friendly feedstock which can contribute to diversifying our energy portfolio. Electricity, transportation fuels, chemicals, and materials currently produced from petroleum and natural gas can instead be produced from biomass resources. These resources include crops and trees; industrial, municipal and forestry residue; and byproducts from production processes in the agricultural, forest products, and pulp and paper industries. This prospect holds great promise for our economy and is critical for our strategic security.

The ***Vision for Bioenergy and Biobased Products in the United States*** (Vision) established by the Biomass Research and Development Technical Advisory Committee defines a set of achievable quantitative goals to help the United States transition from a fossil-fuel-based economy to a biobased economy. These goals will help achieve greater economic and resource sustainability, economic security, and a healthier environment. Looking to the future, the Vision can be used by policy makers, educators, government, and industry as a tool to guide the nation toward a viable biomass-based economy.

Realizing the Vision goal of a viable bioenergy and biobased products industry will result in important benefits in each of the areas discussed in the remainder of this section.

BALANCE OF TRADE

In 2005, the United States relied on imported oil to meet 65 percent of its demand for crude oil and petroleum products, up significantly from previous decades.[7] In the U.S., crude oil imports increased 194 percent from an average of 3,426 thousand barrels per day in 1984 to 10,055 thousand barrels per day in 2005.[8] This trend will continue unless a concerted effort is made to increase energy production from domestic resources and/or reduce energy consumption. The U.S. balance of trade for petroleum was at a deficit of $231 billion in 2005 – representing 30 percent of the total U.S. trade deficit.[9] Increasing demand combined with spikes in petroleum prices suggest that U.S. petroleum imports will further exacerbate the U.S. trade deficit. More critical to the deficit is the price inelasticity of oil. Even small changes in the price of oil have a large impact on the deficit. According to The Economic Policy Institute, the dramatic increases in the cost of petroleum products and the volume of imports were responsible for more than one-third of the increase in the trade deficit in 2004.[10] If domestically produced biobased products and bioenergy can begin to replace a portion of petroleum products, those dollars could remain in the U.S. and provide an opportunity to fuel domestic economic growth.

ECONOMIC GROWTH

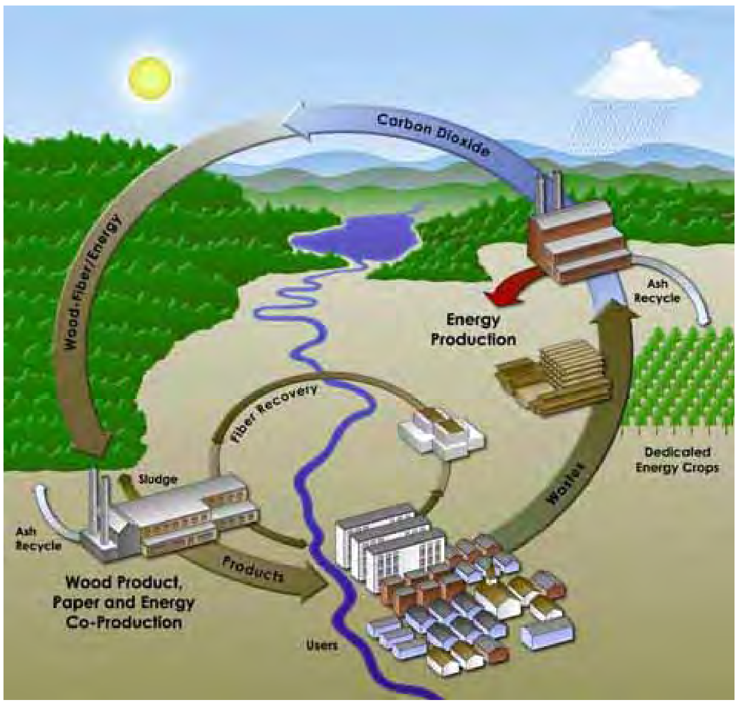
Biomass resources are varied, ranging from agricultural crops and residues to forest resources and energy crops. They are available in every region of the United States. Achieving the Vision will infuse dollars back into the domestic economy by creating a market for business output, generating income, and encouraging capital investment, which, in turn, will further increase the demand for business output – the "multiplier effect." In essence, for rural America, renewable energy means creating new markets, industries, and jobs. The inherent wealth of biomass feedstock in rural land provides opportunities for rural distributed energy systems, and localized biomass production and processing facilities. The untapped potential of rural America can help provide a conduit for the renewbale energy industry to grow.

In 2004, the ethanol industry alone supported creation of 147,000 jobs in all sectors of the economy, boosted U.S. household income by $4.4 billion through increased economic activity and new jobs, and added $1.3 billion in federal tax revenue and $1.2 billion in state and local tax revenues.[11] Such biomass-based industries will help provide new markets and product diversification to farmers, ensuring economic vitality for years to come. Moreover, new value products from forest and agriculture industry residuals will open new market opportunities for these industries, for example, conversion of biomass — including forest residues, agricultural residues and spent pulping liquor (black liquor) — into ethanol and syngas; and conversion of syngas, carbonaceous solids and oils into fuels, power, chemicals (such as hydrogen, hydrogen carriers, and butanol) and other high-value materials.

ENVIRONMENTAL ISSUES

Biomass technologies can help to reduce global warming, the principal environmental impact of petroleum consumption. Since biomass has relatively low net (fuel-cycle) carbon emissions, substituting biofuels and biobased products with those derived from petroleum can result in significantly lower greenhouse gas emissions (see Exhibit 1).

Exhibit 1: Carbon Cycle: Benefits of Biomass



***Source:** Oak Ridge National Laboratory*

Biomass has the biggest potential near-term impact in the transportation sector, which accounts for 65 percent of U.S. oil consumption and is the predominant source of air pollution.[12] The transportation sector produced 1,770 teragrams of CO_2 in 2003, accounting for 32 percent of the total U.S. CO_2 emissions. The transportation sector also was responsible for as much as 90 percent of carbon monoxide (CO) in urban air — both gases contribute either directly (CO_2) or indirectly (CO) to global warming.[13,14] Biomass could also have an important impact on power generation through co-firing, gasification, and pyrolysis technologies, especially if biopower replaces electric generation that would otherwise have been generated from coal. Electricity generators rely on coal for over half of their total energy requirements and accounted for 93 percent of all coal consumed for energy in the United States in 2003.[15] Electricity generators consumed 35 percent of U.S. energy from fossil fuels and emitted 41 percent of the CO_2 from fossil fuel combustion in 2003.[16]

The Clean Air Act mandated that the Environmental Protection Agency establish emission standards for NO_x and other pollutants. Currently, CO_2 emissions are not regulated as a pollutant under the Clean Air Act. As the contribution of CO_2 to global warming has become more widely accepted, however, some states have independently adopted limits on vehicle tailpipe CO_2 emissions, and it is possible that other CO_2 emission limits may be imposed in the future. Biopower and co-firing can help industry meet such new requirements. Similar benefits could be achieved by biorefineries which produce a suite of fuels, power, and biobased products. Reducing the amount of fossil fuels we use and replacing them with cleaner-burning bioenergy will also decrease air pollution and related public health costs. Sustainable production of forest and agricultural feedstocks provides bioenergy as well as continual CO_2 uptake by well-managed crops and forests.

Net Carbon Benefits — Since bioenergy is made from crops and trees that absorb carbon dioxide, the cycle of their growth and oxidation is carbon neutral and their substitution with petroleum-based fuels and feedstocks can help to reduce net greenhouse gas emissions. By increasing growth rates and efficient production methods, we can potentially reduce CO_2 concentrations by increasing our use of bioenergy.

There are other environmental benefits associated with biomass utilization. For example, we could remove, and use for energy, excessive levels of biomass found on our forest lands. Active management may reduce the risk of catastrophic wildfires, provide better wildlife habitat, allow forests to become more resilient to insects, disease and drought, and enhance the rate of growth of trees. Benefits to the environment may include enhanced air and water quality because excess forest and woodland growth is used rather than burned in debris piles. Conservation activities can be completed using fast-growing crops, wood plantations, and agro-forestry that provide clean water and soil protection.

ENERGY DIVERSITY AND SECURITY

The issue of energy security in the United States is largely an issue of oil and gas supply security. The United States has only 4 percent of the world's population but consumes about 25 percent of the world's produced oil.[17] Vulnerability to even short-term disruptions in oil and gas supply was illustrated during the Gulf Coast hurricanes of 2005. The nation is dependent on foreign sources of oil, with 65 percent of its 2005 annual oil consumption coming from imports, including approximately 17 percent from the Persian Gulf region.[18] The price of crude oil has also increased from an annual average of $36.98 per barrel in 2004 to $50.23 per barrel in 2005, and $59.30 per barrel in 2006 to date.[19]

U.S. reliance on oil imports also results from indirect oil imports in the form of manufactured goods. This includes the energy used to produce the goods along with the petroleum-based materials that comprise products such as plastics. Often countries that manufacture these goods are themselves reliant on imported oil, further exacerbating U.S. and global energy security issues. Although the Energy Information Administration (EIA) and the International Energy Agency (IEA) do not make estimates of these indirect imports, analysts speculate it would add at least 1.0 million barrels per day (MMBD) to the current 10.1 MMBD of total U.S. oil imports.[20]

Although not matching the pace of petroleum, imports of natural gas have also increased in recent years and imports accounted for 20 percent of total consumption in 2005.[21] This has been led largely by a near tripling in liquefied natural gas imports. There has been a dramatic increase in construction of liquefied natural gas (LNG) terminals. Currently, there are five LNG terminals in the U.S. with a capacity of about 5.2 Bcf/day.[22] Another 13 have been approved by the Federal Energy Regulatory Commission (FERC) and the U.S. Coast Guard which will bring the total to 22.1 Bcf/day.[23] An additional 25 LNG terminal sites in the U.S. have been proposed to FERC and the Coast Guard.[24]

It seems only prudent that the U.S. government and industry begin to make significant investments to diversify the country's portfolio of energy resources. The U.S. needs to build greater resiliency into its energy sector to lessen the impact of natural disasters, external attacks, industry downturns, or other factors that may impact energy supply.

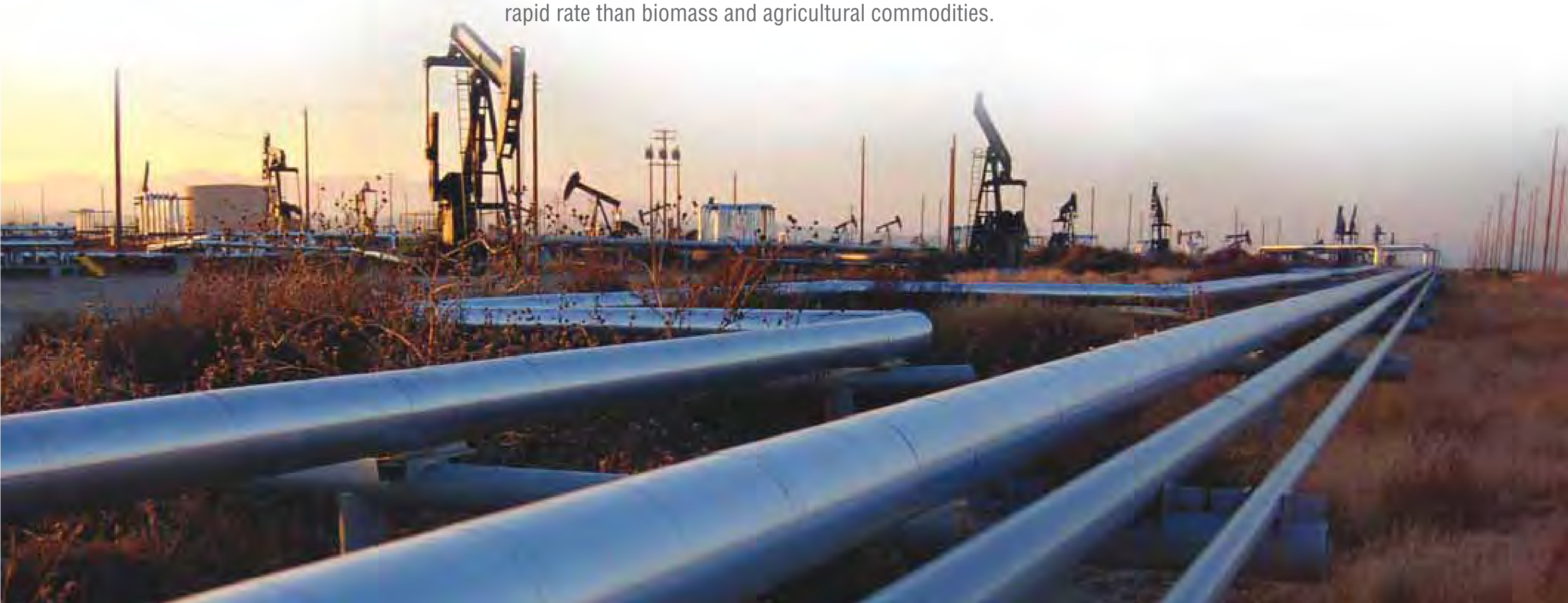
Geographically dispersed biorefineries could provide an alternative and an additional flow of domestically produced products that could partly reduce the economic insecurity stemming from increased dependence on fossil fuels. Further, biofuels can be a component of the renewable hydrogen energy future, and thus this effort supports both near- and long-term energy and environmental security goals. Biomass feedstocks can replace fossil fuels to support the hydrogen economy, limiting greenhouse gas emissions and detrimental reliance on foreign petroleum suppliers. Biomass can also provide a feedstock for other advanced biobased fuels such as biobutanol.

SUSTAINABLE ENERGY SUPPLY

World oil demand continues to increase with the U.S. leading the way. Continued economic expansion in populous countries such as China and India is further fueling this demand. In the coming decades, world oil production is predicted to "peak" after which worldwide production of oil will begin to decrease, raising the oil prices rapidly. Analyses published over the past three decades have varied widely in their estimate of when world oil production will peak, ranging from as early as 1989 to 2050.[25] A recent EIA study estimates world oil production to peak in 2044.[26]

The basic counter argument to any prediction of early "peak oil" production is that new technologies and increased investment can overcome any production barrier. The IEA estimated that the total necessary investment cost for worldwide upstream operations and transport of oil by 2030 would amount to $16 trillion – or roughly $568 billion a year, between 2003 and 2030.[27] A study by the Center for Strategic and International Studies suggests that this estimate may actually be too conservative.

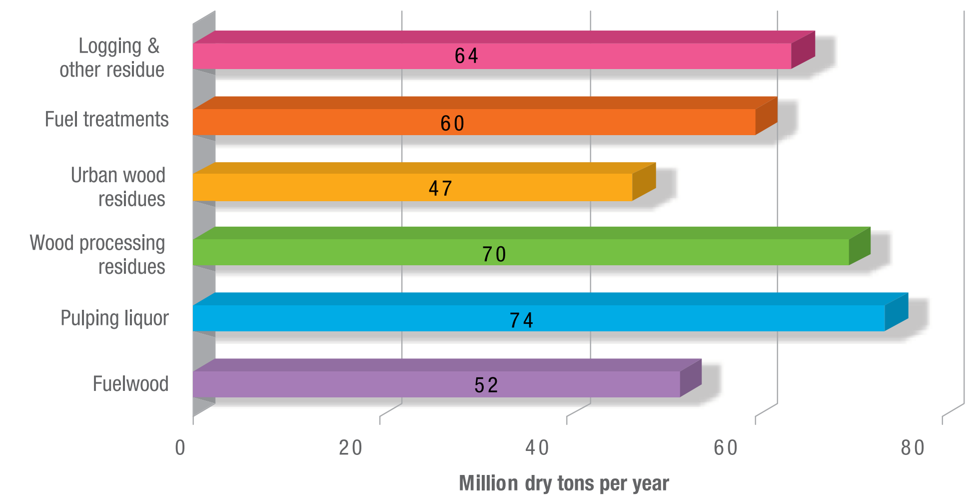
No matter what the exact date of the expected peak in oil production, looking at the increasing reliance of the U.S. economy on fossil fuels and the uncertainty of the long-term future of fossil fuels, the United States must begin to prepare for a transition to alternate energy now. To start with, the United States must begin to make significant investments to diversify its portfolio of energy resources. Geographically distributed biorefineries could produce a steady flow of bioenergy and bioproducts into the U.S. economy, reducing some of our reliance on petroleum imports and reducing economic insecurity from threats, both domestic and external. Regardless of when peak production is reached, the cost of crude oil and natural gas will likely continue to increase at a more rapid rate than biomass and agricultural commodities.

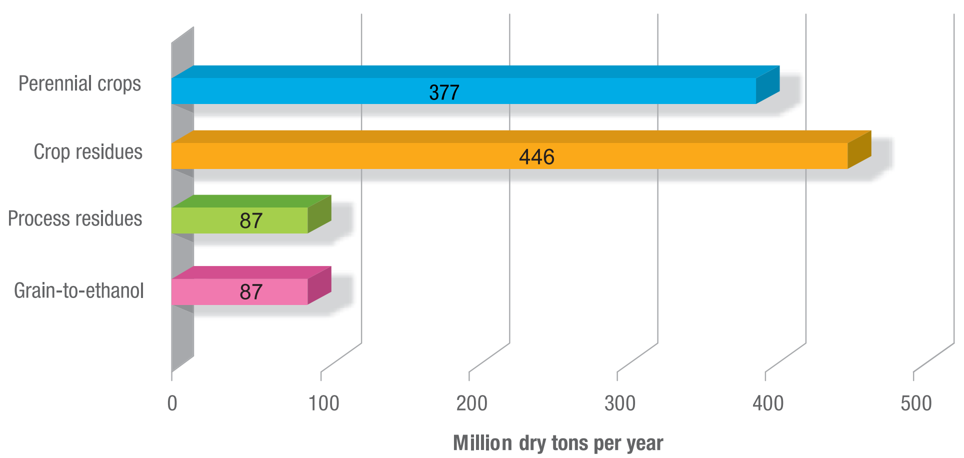


Current Status of Bioenergy and Biobased Products

Currently, biomass accounts for about 4 percent of the total U.S. energy consumption but has the potential to contribute much more. Biomass resources are diverse and are found in every state in the United States. Feedstocks from the agriculture and forestry industries such as corn stover or spent pulping liquor can be converted into liquid fuels, power, chemicals and other higher-value materials. According to a 2005 report by U.S. Department of Agriculture (USDA) and U.S. Department of Energy (DOE), there are approximately 1.3 billion tons of biomass available in the United States for conversion to fuels, power and products (Exhibit 2).[28] Biomass is used to produce heat and power in industry, to produce electric power for sale to the electrical grid, and to produce biobased fuels such as ethanol and biodiesel. Biomass is also used to produce a range of chemical and material products that are otherwise produced from petroleum-based feedstocks.

Exhibit 2: Summary of Potential Forest and Agriculture Resources





Source: ***Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. 2005. It should be noted that the forest feedstock analysis looks only at residues and wastes and does not take other wood sources into account.***

Heat and power produced by biomass was estimated at 2.1 quadrillion Btu (quads) in 2004, and accounted for about 3 percent of the market share for power production. Consumption of biofuels in the transportation sector was approximately 2.1 billion gasoline-equivalent gallons in 2004, about 1.2 percent of the market share for transportation fuels.[29]

In its original Vision, the Committee set aggressive goals for biofuels, biopower and biobased products for 2010, 2020, and 2030. In updating its Vision, the Committee evaluated the current status of biofuels, biopower, and bioproducts in the United States to track the progress toward achieving the original goals stated in the Vision. It found that the U.S. is on track to meet the Committee's original biofuels goals for 2010, but is not on track to meet its 2010 goals for biopower. It is difficult to assess progress in achieving its goals for biobased products due to lack of data.

Liquid fuels in transportation are measured in gallons, with the most common fuel being gasoline. The energy content of each fuel type is different. The Btu content for gasoline (130,000 Btu/gallon) is higher than the content for ethanol (89,000 Btu/gallon) or biodiesel (128,000 Btu/gallon). For comparison purposes, the Vision uses **gasoline-equivalent gallons** when discussing transportation fuel consumption.

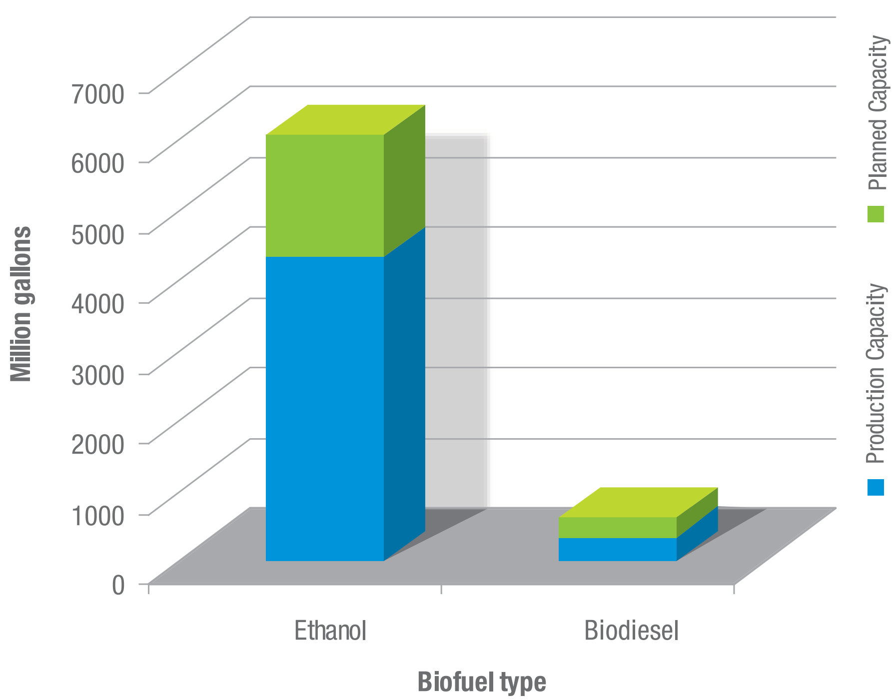
BIOFUELS

The current U.S. biofuels production capacity (existing and planned) is illustrated in Exhibit 3. As of January 2006, there exists over 4,336 million gallons per year of ethanol production capacity with over 1,743 million gallons per year in new planned capacity.[30] Current dedicated biodiesel and oleochemical production capacity is estimated to be 395 million gallons per year with 714 million gallons per year in planned capacity.[31]

Overall demand for transportation fuels has increased 19 percent in the past 10 years with the vast majority of this growth reliant on imported petroleum.[32] Increased use of domestically produced biofuels in the transportation sector represents a near-term opportunity to help offset petroleum demand and rising oil imports. Biofuels include ethanol blended with gasoline, such as E85, biodiesel, or other advanced biofuels still under development.

As shown in Exhibit 4, there has been sizeable growth in consumption of virtually all biofuel categories, reaching a total consumption of 2.1 billion gasoline-equivalent gallons in 2004 – a 1.2 percent capture of the total annual vehicle fuel consumption in the United States.[33] If the biofuel consumption growth continues at this rate, the original Vision goal of 8.0 billion gasoline-equivalent gallons or 4 percent of market share by 2010 can be reasonably met. This will exceed the Renewable Fuels Standard (RFS) established by the Energy Policy Act of 2005 (EPAct), which aims to double the amount of ethanol and biodiesel in the U.S. fuel supply over the next seven years. The RFS requires 7.5 billion gallons of biofuels (5 billion gasoline-equivalent gallons) production by 2012.

Exhibit 3: Biofuels Production Capacity, January 2006



***Sources:** 2006 Annual Industry Outlook, Renewable Fuels Association; Fact Sheet: U.S. Biodiesel Production Capacity, May 2006, National Biodiesel Board.*

Exhibit 4: Estimated Consumption of Biofuels and Traditional Fuels in the United States 2001-2004 (Thousand Gasoline-Equivalent Gallons)

	2000	2001	2002	2003	2004	Avg. Annual % Change 2000 04
E85	*12,084	14,623	17,783	20,092	22,405	14%
E10	1,085,800	1,143,300	1,413,600	1,792,900	2,052,000	14%
Biodiesel	6,816	7,076	16,917	26,758	36,599	31%
Total Biofuels	**1,104,700**	**1,164,999**	**1,448,300**	**1,839,750**	**2,111,004**	**15%**
Gasoline	125,720,000	127,768,000	131,299,000	132,961,000	136,374,000	2%
Diesel	36,990,370	37,085,270	38,305,630	39,930,170	40,740,760	2%
Total Fuel Consumption	**163,032,677**	**165,201,691**	**169,983,219**	**173,303,895**	**177,561,958**	**2%**

Source: *Alternative Fueled Vehicles. Renewable and Alternative Fuels. Energy Information Administration.*[34]

**E85 in 2000 includes 13,000 gasoline-equivalent gallons of E95. 2001-2004 E95 is zero.*

Biofuels

Fuel ethanol (C_2H_5OH) .... An anhydrous denatured aliphatic alcohol intended for gasoline blending.

Oxygenated gasoline .... Finished motor gasoline, other than reformulated gasoline, having an oxygen content of 2.7 percent or higher by weight.

E10 .... A fuel containing a mixture of 10% ethanol and 90% gasoline.

E85 .... A fuel containing a mixture of 85% ethanol and 15% gasoline.

E95 .... A fuel containing a mixture of 95% ethanol and 5% gasoline.

Biodiesel .... Produced through transesterification, a process in which organically derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form ethyl or methyl ester. Biodiesel can be made from soybean or rapeseed oil, animal fats, waste vegetable oils, or microalgae oils.

Fischer-Tropsch (FT) Synthesis ..... One route to produce green fuels is the combination of biomass gasification (BG) and Fischer-Tropsch (FT) synthesis, wherein biomass is gasified and, after cleaning, the biosyngas is used for FT synthesis to produce long-chain hydrocarbons that are converted into “green diesel” (e.g., biodiesel and ethanol).

Quads — Energy is measured in British thermal units or Btus. U.S. energy consumption's order of magnitude is in **quads,** short for one quadrillion (10^{15}) Btus. A Btu is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit and is equal to 252 calories. For example: a gallon of gasoline contains 124,000 Btu; a kilowatt of electricity contains 3,412 Btu; and in 2004, U.S. energy consumption was about 100 quads (including all residential, commercial, transportation, industrial and electric power sector energy consumption).

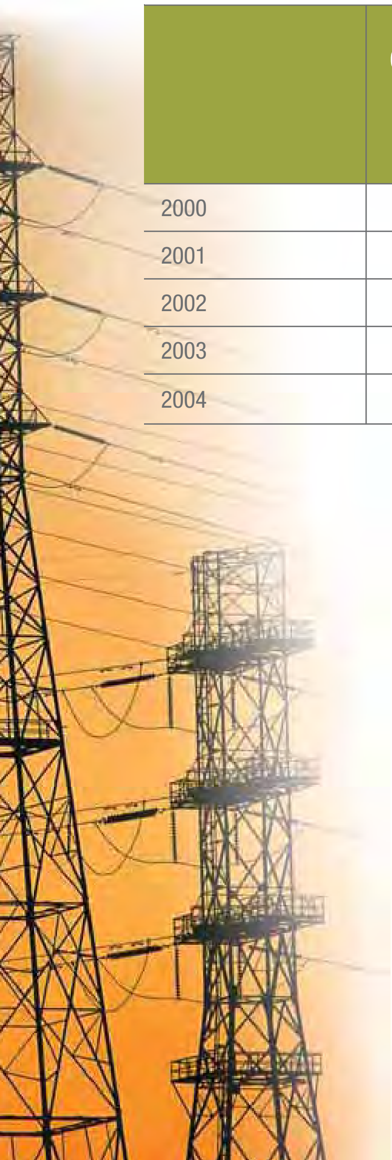
BIOPOWER

The United States is not on track to reach the 2010 Vision goal for biopower of 3.3 quads or 4 percent of market share. Biopower includes biomass resources used to produce heat and power in the industrial sector for both onsite use and sale to the grid. Biopower also includes biomass used for electric power production by the utility sector. As shown in Exhibit 5, the use of biomass to produce biopower has been relatively unchanged since 2000, decreasing marginally from 2.23 quads in 2000 to 2.13 quads in 2004. The Committee recognizes that although combined heat and power is an important aspect of the "biorefinery concept" and is important to the overall objectives of achieving the Vision, the value-added nature of biofuels, biochemicals, and other bioproducts will have a more significant economic impact in displacing fossil energy sources.

Exhibit 5: Biomass Share of Electricity and Heat Demand in Utilities & Industry (Quadrillion Btu)

	Biomass Consumption for Heat & Power (Industrial Sector)[a]	Biomass Consumption for Electric Power (Electric Utility Sector)[a]	Total	Total Energy Consumption (Industrial & Electric Utility Sectors)[b]	Biomass Share of Electricity & Heat Demand in Utilities & Industry[a]
2000	1.78	0.45	2.23	72.93	3.06 %
2001	1.59	0.45	2.04	70.03	2.92 %
2002	1.56	0.51	2.08	70.86	2.94 %
2003	1.53	0.52	2.05	70.61	2.91 %
2004	1.62	0.50	2.13	71.93	2.96 %

Source: *[a] Renewable Energy & Alternative Fuels. EIA.[35] [b] Annual Energy Review. EIA.[36]*



BIOPRODUCTS

As it has since the early 1900s, the United States continues as the world's leader in chemicals production. In 2005, the U.S. chemicals industry produced 23 percent of the world's total chemicals shipments.[37] The chemicals industry is energy intensive, relying on oil and gas not only for process energy but also using petroleum as feedstock for the manufacture of many of its products. In 2004, the energy equivalent consumed by the U.S. chemicals industry for these purposes amounted to 6.4 quads or 6.4 percent of the total U.S. energy consumption.[38] Energy used for fuel, power, and electricity accounted for 3 quads of this total, with the remaining 3.4 quads used for hydrocarbon feedstocks.[39] These hydrocarbon feedstocks are sourced primarily (99 percent) from petroleum and natural gas, with the remaining 1 percent from coal and biomass.[40]

The Biomass R&D Technical Advisory Committee defines targeted biobased products as any product generated from biomass that would otherwise be produced using fossil fuel feedstocks.

When the original Vision document was published in 2002, the production of biobased textile fibers, polymers, adhesives, lubricants, soy-based inks, and other products was estimated at 12.8 billion pounds per year or roughly 5 percent of the market share (see Exhibit 6). Based on the 2005 estimate shown in Exhibit 6, biobased products now constitute about 17.6 billion pounds per year, or about 8 percent of the total target market share.[41] However, note that these estimates use some references that are not updated annually for tracking the volume of bioproducts. The production entry for Cellulose Polymers has not changed from the 2002 baseline, not because the market has not grown, but because more recent data reflecting the current state of its market is unavailable.

Due to lack of publicly available data on production of biobased products, it is uncertain how close U.S. industry is to achieving the original Vision goal of capturing 12 percent market share of products by 2010. In its updated Vision, the Committee has expanded the list of key biobased products which it will include in its slate of biobased products. In addition to those products listed in Exhibit 6, new biobased products which are projected to enter the market are: polylactic acid from lactic acid, succinic acid, 1,3 propanediol (PDO), polyhydroxy-alkonoate (PHA), and 3 hydroxyropionic acid (3-HP). These biobased products will be direct replacements for current petrochemicals such as polyolefin thermoplastics (e.g., polyethylene and polypropylene). Although there are many unknowns with respect to current bioproduct production capacity, the outlook is very promising for bioproducts.

As in the energy sector, diversifying the chemical industry's feedstock base to include more biomass can help to ensure greater security and reduce vulnerability to oil and gas price swings. Increasing prices for crude oil and natural gas have contributed to rapid price increases for commodity chemicals such as propylene, ethylene, and benzene, as well as their downstream intermediates, ultimately leading to cost increases for polymers and resins used in virtually every type of manufactured goods from automotives to textiles. This price squeeze affects the global competitiveness of the entire manufacturing sector from major manufacturers to small fabricators throughout the country. Rising natural gas prices will continue to have a large effect on the chemicals, agricultural, metals, cement and other industries. Major disruptions in oil and gas supply would deliver a serious blow to the U.S. industry, potentially creating a shortage of many key materials for our economy.

Exhibit 6: Estimated Production of Biobased Products (Million Pounds)

	2002	2004 2005
Organic Acids	576	987
Lactic Acid[1]	*114*	*600*
Citric Acid	*462*	*387*
Ethanol for Industrial Use	1757	1971
Starch[2]	3000	6684
Sorbitol[3]	515	697
Glycerol/Glycerine[4]	410	432
Alkyd Resins[5]	550	682
Soy-Based Products[6]	654	934
Specialty Oils/Aroma Chemicals[7] *	9	8.9
Spearmint		*1.7*
Peppermint		*7.1*
Forest Chemicals*	2826	2740
Crude Sulfate Turpentine [8]		*1202*
Tall Oil [9]		*1094*
Pine Rosin[10]		*444.6*
Cellulose Polymers	2500	2500
Cellulose Fibers	*360*	*** NA*
Cellulose Derivatives[11]	*2140*	*696*
TOTAL	**12,797**	**17,635**
% Market share	**5%**	**8%**

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** 2002 estimates for Specialty Oils and Forest Chemicals do not include detailed breakdown of subcomponent quantities due to lack of publicly available data on production.*

*** The 2005 estimate for Cellulosic Polymers uses 2002 totals because no new public information was available.*

Vision Goals

The original Vision established aggressive goals for biopower, biofuels and biobased products defining market share targets for each 2010, 2020, and 2030. These targets were set to benchmark the progress toward achieving the 2030 Vision of a "well established, economically viable, bioenergy and biobased products industry."[42]

The updated Vision does not change the original 2010 goals but recognizes that in some cases the nation is not on track to meet them. The Vision makes minor changes to its 2020 and 2030 goals and establishes 2015 goals to define interim milestones that must be achieved to reach the aggressive targets set for 2020 and 2030. Vision goals are shown below in Exhibit 7.

BIOFUELS

The Committee strongly supports efforts to improve transportation fuel economy. However, the Committee also believes that it is critical to diversify our portfolio of transportation fuels and that biofuels should account for 4 percent of transportation fuel demand by 2010, 10 percent by 2020, and 20 percent by 2030. Biofuels consumption in 2004 was 2.1 billion gasoline-equivalent gallons, or 1.2 percent of the market share of total motor vehicle fuel consumed. If current trends are an indication of future demand for biofuels, the original 2010 target can be met. It is the longer-term goals which present a challenge. DOE has established an objective to achieve cost-competitive production of cellulosic ethanol by 2012 per the President's Advanced Energy Initiative and to displace 30 percent of 2004 levels of gasoline consumption with biofuels by 2030. Thirty percent of the 2004 market for gasoline consumption is about 60 billion gallons of ethanol, or 40 billion gasoline-equivalent gallons.

The Vision's long-term goal for biofuels is to capture 20 percent of the 2030 market for transportation fuels. Using forecasts for 2030 transportation fuels consumption, this requires production of an estimated 51 billion gasoline-equivalent gallons or 85 billion gallons of ethanol.

Exhibit 7: Vision Goals

	Units	2000	2004	2010	2015	2020	2030
Biofuels[43]	Market share (%)	0.7	1.2	4.0	6.0	10.0	20.0
	Consumption (billion gasoline-equivalent gallons)	1.1	2.1	8.0	12.9	22.7	51.0
Biopower[44]	Market share (%)	3.0	3.0	4.0	5.5	7.0	7.0
	Consumption (quadrillion Btu)	2.0	2.1	3.1	3.2	3.4	3.8
Bioproducts[45]	Production (billion lbs)	12.8	17.6	23.7	26.4	35.6	55.3

† Estimate for biobased products are for 2001 as reported in 2002 Vision.

BIOPOWER

Biopower constitutes biomass-derived heat and electric power produced in industry and utilities (see Exhibit 5). It includes power produced from biomass used in co-firing, waste-to-energy conversion, gasification of biomass and possibly liquid fuels. It does not include residential and commercial sector use of wood energy. The United States is not currently on track to meet original Vision goals for biopower. The Committee will continue to maintain its challenging goals for biopower, believing that it should represent 4 percent of energy use in industry and utilities by 2010, 5.5 percent by 2015, and level off at 7 percent by 2020. In order to meet its biopower goals, strong incentives and policies are needed. A good example in which state and local governments are leading biopower development is through implementing the Renewable Portfolio Standards (RPS) policy. RPS require a certain percent of the total energy portfolio to come from renewable sources of energy such as wind, solar, or biomass.

BIOBASED PRODUCTS

The Committee believes that production of biobased products should increase from its current estimated baseline of 17.6 billion lbs to 23.7 billion lbs by 2010, 26.4 billion lbs by 2015, 35.6 billion lbs by 2020, and 55.3 billion lbs by 2030. The original Vision defined biobased products as biobased textile fibers, polymers, adhesives, lubricants, soy-based inks, and other products. As previously mentioned, the Vision update defines biobased products as any product generated from biomass that would otherwise be produced using fossil fuels. The Committee adopted this change to highlight the important role that biomass can play in diversifying chemical industry feedstocks.

Achieving the Vision Goals

The Vision will provide the framework for action to achieve our goals. However, major progress is needed in several areas. A critical component is the need for a biomass champion. Industry has been hesitant to shift from petroleum to biomass, citing the huge cost to do so. A well-organized movement led by an industry champion must, therefore, be launched to encourage lawmakers to implement policies and provide critical incentives and funding needed to begin the transition to a bioeconomy. Further, long-term public policies are needed to create an environment which reduces the risk to investors. This would enable funding and deployment of demonstration projects to prove the technical and commercial feasibility of existing biomass technologies. Public- and private-sector R&D is working toward decreasing the cost of harvesting, transporting, storing, handling and converting feedstocks, and deploying and commercializing biomass technologies. The updated ***Roadmap for Bioenergy and Biobased Products in the United States*** will further outline the strategies needed in each of these areas.

RESEARCH AND DEVELOPMENT

Important research priorities have been outlined in documents such as the Committee's ***Roadmap for Bioenergy and Biobased Products in the United States***, ***Feedstock Roadmap***, and ***Agenda 2020: Advancing the Forest Biorefinery***. Biomass research and development pathways are outlined in the Committee's Roadmap.

Areas of focus for research and development include the following:

- Improving basic plant science to increase sustainable biomass production rates
- Ensuring the ability of agricultural and forest lands to supply large volumes of biomass in a perpetually reliable manner without degrading our resources and environment and identifying the environmental factors associated with expanded production of biofuels and biobased products, including land-use changes; effects on biodiversity; use of water; runoff of pesticides, herbicides and nutrients; effects on soil and water quality; erosion; and net emissions of greenhouse gases and criteria pollutants
- Optimizing the utilization of traditional crop and forest resources and byproducts while also working on developing new and improved feedstocks, sustainable management systems, more cost-effective harvesting systems, and improved transportation systems
- Developing land management practices that will be necessitated by the transition from the conventional roles of agriculture and forestry to the role of providing energy, fuels, and a wider variety of biobased products and changing land management policies to allow longer-term and larger projects
- Reducing harvest, transportation, conversion and manufacturing costs
- Improving the efficiency and effectiveness of priority biological and thermochemical pathways
- Reducing the cost of fermentation
- Enabling greater conversion of lignocellulosic biomass
- Developing more robust enzymes and catalysts
- Developing new uses for biomass and improving the competitiveness of biomass products in chemical markets
- Analysis of the impacts from reduction in corn and soy exports as they transition to use in bioenergy

A successful research strategy will require sufficient funding and supportive policies to encourage federal, university, industry, and state R&D partnerships for collaborative research and deployment.

AGRICULTURAL AND FOREST PRODUCTION

The role of agricultural and forest production for human food, animal feed, and fiber could be transformed to include additional bioenergy, bioproducts, and fuels. There is a need to identify the environmental factors associated with expanded production of biofuels and biobased products, such as land-use changes; effects on biodiversity; use of water; runoff of pesticides, herbicides and nutrients; effects on soil and water quality; erosion; and net emissions of greenhouse gases and criteria pollutants. The critical sectors of agriculture and forestry products need to be the growth engine for new sustainable jobs, ensuring an improved standard of living. Compared to agricultural crops and residues, wild grasses and other energy crops such as wood and wood residuals derived from forest resources offer many compelling advantages as a process feedstock. It will be important for R&D to improve feedstock production efficiencies, provide the technologies for sustainable and reliable biomass resource production management and harvesting, and develop required infrastructures in local communities. Agricultural and forest-based commodities must continue to generate incomes adequate to produce a profit for farmers and forest land owners. It is vital that they remain in the economic chain and that they too benefit from the biobased economy. To this end, it is imperative that realistic business models be developed and communicated to farmers, ranchers, the pulp and paper industry, and forest owners/operators, along with public officials and industry, to spur public and private investment in necessary production, land management, harvesting, transportation, and storage infrastructure expansion.

POLICY

Long-term policies and financial incentives should be developed to promote biomass applications across all sectors of the economy. These could include effective tax incentives for greater flexibility in utility interconnection policies, green purchasing requirements, emission taxes or regulations, and/or tax credits for research and investments in renewable energy. The Committee believes that market-based mechanisms should credit the environmental, energy, and security advantages of bioenergy and biobased products. Moreover, government agencies should provide leadership by purchasing biobased products, biofuels, and biopower. Bioproducts equivalence testing and preferred purchase of bioproducts should be a priority. Opportunities for biobased products will no doubt increase with new legislation such as that guiding the Federal Biobased Products Preferred Procurement Program (FB4P). The federal government should help communicate federal standards for purchasing biobased products and encourage states to adopt similar standards. The existing lack of data on biobased products makes it difficult to measure progress in achieving Vision goals and further research is needed to benchmark and track the role of biobased products in the U.S. economy.

DEMONSTRATIONS

Commercial-scale demonstration projects are needed to help prove the techno-economic viability of biomass technologies and biorefineries to potential investors, decision-makers and others, this will act as a catalyst for opening credit markets. Greater investment is needed on prototyping and education to address this important gap in realizing the benefits of biomass technology advances. Demonstration of biorefineries will illustrate the ability of the agriculture and forest industries to maximize utilization of energy streams, minimize waste and develop new value products.

PARTNERSHIP/CHAMPION

Efforts such as the forest and paper industry's Agenda 2020 Technology Alliance, and the 25x25 Initiative are stressing the important role of biomass technologies. These are coalitions of various agriculture- and forest-related industry groups and researchers who have come together to address common goals related to their industries. But industries which comprise the bioeconomy are varied and not well coalesced, which has hindered progress. An association or industry-led coalition is needed to represent one voice for the biomass industries. By establishing a champion and setting aggressive targets, the Vision can help farmers, forest land owners, refiners, developers, and other members of the biomass industries to come together in their efforts toward achieving a viable bioeconomy.

FINANCING

The capital investment required will be significant to develop and establish new feedstock production systems and build new bioenergy, biofuel and biochemical production plants and distribution infrastructure. Financing needs to be complimented by supporting long-term planning, assessments, and policy. Business models are needed to quantify investment requirements as well as operating costs and returns. Realizing the Vision will require significant increases over the current federal investments. Federal agencies should identify sources of sustained unencumbered financing to invest in biomass technology, research, development, and deployment. Increased use of public/private partnerships should be pursued, as well as loan guarantees and other financial incentives outlined in the Energy Policy Act of 2005. In addition, greater investment should be sought from the automotive, chemicals, fuels, and other industries with vested interests.

PUBLIC EDUCATION AND OUTREACH

A number of common misconceptions impede a positive public perception of biomass. These include, but are not limited to, issues of biomass availability and net energy benefits. A 2005 report produced by the U.S. Departments of Agriculture and Energy showed that currently there are enough sustainable resources available to offset 30 percent of current annual petroleum demand.[46] In terms of energy benefits, a July 2005 study, ***Updated Energy and Greenhouse Gas Emissions Results of Fuel Ethanol***, by the Center for Transportation Research, Argonne National Laboratory compares the net energy balance of corn ethanol with that of petroleum. The report states that ethanol requires 0.74 Btu of input compared to 1.23 Btu of input for petroleum to produce the same output of energy.[47] It is important to educate the public and the biomass community on the real costs associated with using fossil fuels, including negative environmental and geopolitical externalities, and balance of trade effects, and on the sustainability benefits of biomass. The biomass community should disseminate success stories highlighting the benefits of biobased products and also educate consumers that biomass is available nationwide and that it can benefit local economies throughout the country. Educating the public has long been the domain of the Land-Grant University Extension system with local educators in almost every county in our nation. The Extension system should become fully informed and engaged in this important public educational outreach.

WORKFORCE EDUCATION

Universities should develop research and development programs in biomass, which will result in engagement of the faculty with this important issue. Academic departments should incorporate biomass-related topics into undergraduate and graduate educational curricula that will prepare future professionals for employment in the biomass economy. Existing agency R&D programs should be further developed to supply critical science and technology for feedstock production, management, harvest, transportation, conversion, and distribution.

The U.S. workforce has traditionally been trained to use petrochemicals. Transitioning to a bioeconomy requires a workforce trained and educated in carbohydrate chemistry and the science related to biomass production and conversion. Universities should have access to national resources to develop research and educational programs in biomass that will catalyze the creation of undergraduate and graduate curricula in carbohydrate, protein, and lignin chemistry, and other relevant science and engineering topics to support the emerging biomass industry.

Multi-disciplinary projects are required in order for the bioeconomy to be successful. This will require involvement by the forest, agriculture, chemicals, finance, and other sectors. The capacity to transition to and be successful in a bioeconomy is an important step in accomplishing the Vision goals. Future scientists and engineers need to train with biomass feedstocks, supply systems, conversion processes, and applications so that our nation has the creative, well-prepared workforce that will help the nation realize the Vision.

CHARTING A ROADMAP

Lessons learned from the original 2002 Vision show that without effective policies and well-planned R&D, efforts to achieve the Vision goals will be ineffective in reaching the accelerated goals for biomass utilization in the near future. The updated Vision will be the basis for future regional Roadmap workshops to chart the technical research, development, and demonstration activities needed to achieve a biobased economy. These regional Roadmap workshops will also outline the institutional and policy changes needed to remove the barriers to economically and environmentally sound development of sustainable biomass systems.

End Notes

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41 Lack of data on biobased products makes it difficult to measure progress in achieving Vision goals. Further research is needed to benchmark and track the role of biobased products in the U.S. economy. To this end, the U.S. Department of Energy is in the process of conducting data research to gain better data on current production levels of bioproducts and also to solicit the industry's input on the Committee's revised Vision targets for bioproducts.

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Appendix A

Vision Workshop Participants

Name	Organization
Tom Binder	Archer Daniels Midland
David Canavera	MeadWestvaco
Ralph Cavalieri	Washington State University
Shulin Chen	Washington State University
Roger Conway	Office of the Chief Economist, USDA
Mark Downing	Oak Ridge National Laboratory
Larry Drumm	Biotechnology Group
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Ken Green	BCS, Incorporated
Tom Johnson	Southern Company
Douglas Kaempf	Office of the Biomass Program, DOE
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Michael Manella	BCS, Incorporated
Lori Perine	American Forest &Paper Association
Edan Prabhu	Flex Energy
Cindy Riley	National Renewable Energy Laboratory
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Bryce Stokes	Forest Service, USDA
Larry Walker	Cornell University

Appendix B

Vision Peer Reviewers

Name	Organization
Ron Buckhalt	Agricultural Research Service, USDA
Rob Fireovid	Agricultural Research Service, USDA
Emory Ford	MTI Technology Corporation
Michael Foster	BP
John Hanby	Washington Pulp and Paper Foundation
Al Lucier	National Council for Air and Stream Improvement
Bill McKean	University of Washington
Bill Nicholson	Potlatch Corporation (retired)
Jim Simnick	BP

Appendix C

*Vision Review - Interagency Biomass R&D Board Members**

Name	Organization
Co-Chairs	
Thomas C. Dorr	U.S. Department of Agriculture
Alexander A. Karsner	U. S. Department of Energy
Members	
Bruce Hamilton	National Science Foundation
Ashok G. Kaveeshwar	Department of Transportation
Johnnie Burton	Department of the Interior
Sharon Hays	Office of Science and Technology Policy
Dana Arnold	Office of the Federal Environmental Executive

** EPA membership is in transition*

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