BIOREFINERIES

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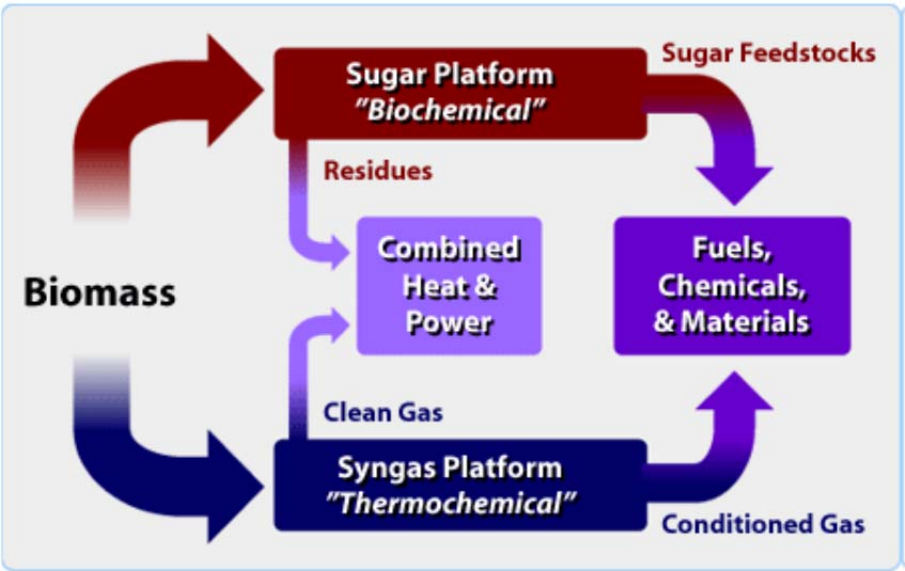
Biorefineries Overview

As a petroleum refinery uses petroleum as the major input and processes it into many different products, a biorefinery uses biomass as the major input and processes it into many different products. Wet-mill and dry-mill corn processing plants and pulp and paper mills can be categorized as biorefineries since they produce multiple products from biomass. Ethanol production facilities produce ethanol and other products from the sugar and starch components of biomass. As of August 2011, the Renewable Fuels Association listed 214 operating ethanol biorefineries with a total production capacity of 14,787 million gallon per year (MGY). Distillers grains, a high-value, protein rich product being used for livestock feed is the major co-product of the existing drymill ethanol biorefineries. Wet-mill ethanol biorefineries have the capacity to produce high fructose corn syrup, and a wide variety of chemical feedstocks such as citric acid, lactic acid, lysine and other products as well as ethanol. Research over the past several years has developed several technologies that have the capability of converting many types of lignocellulosic biomass resources into a wide range of products. The goal is for biorefineries to produce both high-volume liquid fuels and high-value chemicals or products in order to address national energy needs while enhancing operation economics. Pulp and paper mills are existing biorefineries that produce heat, and electricity as well as pulp or paper and some chemicals, but they also have the potential of producing very large amounts of biofuels and biomass power from processing residuals such as bark and black liquor.



Two of the emerging biorefinery platforms are the sugar platform and the thermochemical platform (also known as the syngas platform) illustrated below. Sugar platform biorefineries would break biomass down into different types of component sugars for fermentation or other biological processing into various fuels and chemicals. Thermochemical biorefineries would convert biomass to synthesis gas (hydrogen and carbon monoxide) or pyrolysis oil, the various components of which could be directly used as fuel.

New technologies are being explored for integrating the production of biomass-derived fuels and other products, such as 1,3 propandiol, polylactic acid, and isosorbide, in a single facility.

Figure Source: National Renewable Energy Laboratory, Biomass Program, September 2011. http://www.nrel.gov/biomass/biorefinery.html

Below are ten projects relevant to the development of biorefinery technologies that have been awarded by the U.S. Department of Energy.

Section: BIOREFINERIES
Active U.S. Department of Energy Biorefinery Projects as of September 2011

Project name	Lead Partner/ Project Period	Project cost	Project Description and Status
Integrated Biorefinery for Conversion of Biomass to Ethanol, Power and Heat	Abengoa Bioenergy	N/A	Construction of a 1,200 tons per day commercial biorefinery producing cellulosic ethanol and also power and heat to operate the facility. Agricultural residues would be converted via enzymatic hydrolysis to sugars and fermented into cellulosic ethanol. Agricultural residues along with ethanol plant residual solids and waste water treatment biogas, will be used to generate the necessary heat and power to make the facility energy self-sufficient. Current Status: Award Date: September 2007. Record of Decision was issued January 2011 and supplementary analysis issued July 2011.
Design, construct, build and operate a commercial processing plant as part of an integrated biorefinery to produce lignocellulosic ethanol primarily from corn cobs.	POET Project Liberty	N/A	Demonstration of the benefits of integrating an innovative lignocellulose-to-ethanol biochemical process into an existing dry-grind corn processing infrastructure on a commercial scale. 700 dry metric tonnes per day of lignocellulose, primarily from corn cobs, will be processed to produce 25 million gallons of lignocellulosic ethanol per year. Up to 80% of the corn dry mill's existing natural gas use will be displaced through renewable, alternative energy. Current Status: Award Date: September 2008.
A commercial-scale biorefinery converting biomass into biofuels and power.	Range Fuels	N/A	Plant uses a thermo-chemical process to combine pressure, heat, steam and biomass to produce synthesis gas, or syngas, a mixture ofhydrogen and oxygen that can be converted to a wide range of products. Current Status: Award Date: November 2007.
Demonstration Plant - Biomass to Fischer-Tropsch Green Diesel	Flambeau River Biofuels	N/A	Construction and operation of a thermal gasification and gas-to-liquids plant ingegrated into the Park Falls Mill to produce green diesel for transportation fuel, waxes, and heat and power that replaces natural gas. The plant will produce 1,190 barrels per day of clean, zero sulfur renewable biofuels, waxes, and heat and power that replaces existing natural gas use from forest biomass. Current Status: Award Date: September 2008
Integrated Biorefinery Demonstration Plant producing Cellulosic Ethanol and Biochemicals from woody biomass.	Lignol Innovations, Inc	N/A	Plant for the continuous production of cellulosic ethanol, high purity lignin and furfural from hardwoods. Plant will process 100 tpd of woody biomass, initially local hardwood which is plentiful, and in future test campaigns, softwood and agricultural residues. Current Status: Award Date: TBD
Mascoma Frontier Biorefinery Project	Mascoma Corp.	N/A	Project would initially produce up to 40 million gallons per year of denatured enthanol from approximately 1,300 dry metric tonnes per day of cellulosic materials consisting primarily of wood wastes. Current Status: Award Date: February 2009
NewPage: Project Independence	NewPage Corp.	N/A	Construct & operate a thermal gasification and gas-to-liquids plant integrated into Wisconsic Rapids Mills to replace natural gas use and produce liquid biofuels that will be converted into renewable diesel. Current Status: Award 1 Sept. 2008; Award 2 TBD.
Pacific Ethanol	Pacific Ethanol Inc.	N/A	Design, construct and operate a feedstock flexible demonstration facility producing cellulosic ethanol. Capacity of 2.7 mill gallons of ethanol per year. Current Status: Operational 2009
Red Shield Acquisition	Red Shield Acquisition	N/A	Construct integrated biorefinery that will extract hemicelluloses from wood chips to make biofuel and other specialty chemicals at existing pulp mill. Cellulose & lignin will be maintained in the pulp manufacturing process. Facility will produce 1.5 million gallons per year of Current Status: Award Date: January 2010
Verenium: Jennings 1.4 MGY Demonstration Plant	Verenium Corp.	N/A	Project is operating the demonstration facility to validate findings from the pilot plant operation in the production of cellulosic ethanol from purpose-grown energy crops and agricultural residuals. This demonstration facility is fully integrated from feedstock pretreatment to recovery and distillation of the biofuel product. Current Status: Award Date: September 2008

Source:
U. S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, September 2011,
http://www1.eere.energy.gov/biomass/factsheets.html
Websites of all companies serving as project leaders or key partners on the DOE funded projects.

Below are nineteen projects relevant to the development of biorefinery technologies that have been awarded under the American Recovery and Reinvestment Act (ARRA) of 2009 by the U.S. Department of Energy.

Section: BIOREFINERIES
Active ARRA U.S. Department of Energy Biorefinery Projects as of September 2011

Project name	Lead Partner/ Project Period	Project cost	Project Description and Status
Integrated Pilot Plant to Convert Corn Stover to Fuel and Chemicals	Archer Daniels Midland	N/A	A process has been developed to pretreat and pelletize corn stover, increasing its density by a factor of three. A higher density allows use of ADM's existing agricultural transportation infrastructure for long term storage and reduced transportation costs. Current Status; Award Date: TBD
Integrated Pilot-Scale Biorefinery for Producing Ethanol from Hybrid Algae	Algenol Biofuels, Inc.	N/A	An integrated pilot-scale biorefinery will be constructed that will convert carbon dioxide into ethanol. Algenol is targeting the development of hybrid algae that produce 6,000 galls of ethanol per acre, per year.The biorefinery will consume 2 dry tons of carbon dioxide per day and will produce more than 100,000 gallons of fuel ethanol per year.
Conversion of sweet sorghum biomass to hydrocarbon diesel and chemicals	Amyris Integrated Biorefinery	N/a	Process uses low-risk, yeast-based fermentation of traditional or lignocellulosic-derived sugar feedstocks. The fermentation intermediate is readily recovered as water-immiscible oil. Fermentation waste is treated by anaerobic digestion to reduce effluent and utilize residual sugars for biogas production. Biogas is then converted to hydrogen via steam-methane reformation for use in finishing reactions for a variety of products. Current Status: Award Date: November 2009. Commercial Production: Targeted for 2013.
Alpena Prototype Biorefinery	Alpena Prototype Biorefinery	N/A	Alpena Prototype Biorefinery will be used to demonstrate a modular, technically successful, and financially viable process of making cellulosic ethanol from woody biomass extract in wood processing facilities. It will produce 894,200 USG per year of cellulosic ethanol and 696,000 gallons per year of aqueous potassium acetate. Current Status: Awarded April 2010.
BlueFire Fulton Renewable Energy Project	BlueFire Renewables	$320 Million	The Project would produce in excess of 18 million gallons per year of denatured ethanol from approximately 700 metric dry tons per day of cellulosic materials consisting primarily of wood wastes. Current Status: Award dates: September 2007 and December 2009. Engineering, procurement and construction contract has been awarded to Mastec North America. A front-end level 3 engineering design effort has been completed.
Integrated Pilot Project for Fuel Production by Thermochemical Conversion of Woodwaste	ClearFuels-Rentech	N/A	ClearFuels has developed a process to thermochemically convert a variety of feedstock types that, when combined with Rentech's technology, are anticipated to provide direct replacements for diesel and jet fuel. Current Status: Awarded January 2011. Anticipated operational date: late 2015
Elevance Integrated Biorefinery	Elevance Renewable Sciences	N/A	Process uses novel catalyst developed in the US to convert renewable natural oils into fuels and chemicals. Data will be generated specific for high potential U.S. feedstocks to assist in the design of key sections of a biorefinery which will convert natural oils into fuels and chemicals using the Grubbs olefin metathesis catalyst, develop a non site-specific process design and detailed angeineering, and perform an analysis of the sensitivity of the economics of the process using algae oil. Current Status: Award Date: December, 2009
Enerkem to Use Sorted Waste as Feedstock in Biorefinery	Enerkem	N/A	Biorefinery will convert heterogeneous (mixed) sorted municipal solid waste into ethanol. By converting waste into transportation fuels, the project will increase U.S. energy security, create jobs, reduce greenhouse emissions, and extend the life of the landfill by diverting incoming volume. Current Status: Award Date: March 2010
Gasoline and Diesel from Wood, Agricultural Waste, and Algae R&D	Gas Technology Institute	N/A	GTI will conduct R&D on integrated hydropyrolysis and hydroconversion for the economic conversion of wood, agricultural waste, and algae biomass into fungible gasoline and diesel. Current Status: Award Date: Early 2010
Green Gasoline from Wood Pilot Biorefinery Demonstration Project	Haldor Topsoe, Inc.	N/A	A new economical thermochemical process for the converstion of wood waste and woody biomass to gasoline will be demonstrated. Wood waste and non-merchantable wood product will be sourced from UPM-Kymmene, a pulp and paper company. Current Status: Award Date: Early 2010. Beginning operations by mid-year 2012.
Pilot Integrated Cellulosic Biorefinery Operations to Fuel Ethanol	ICM, Inc.	N/A	Operate the pilot cellulosic integrated biorefinery ujsing a biochemical platform pretreatment and enzymatic hydrolysis technology coupled with a robust C5/C6 co-fermenting organism to refine cellulosic biomass into fuel ethanol and co-products. Proposed process addresses pretreatment, hydroloysis, fermentation, and feed production which represent key technologies needed for the cost effective production of ethanol from cellulosic biomass. Current Status: Awarded January 2010.
INEOS Bio Commercializes bioenergy technolgy in Florida	INEOS New Plant BioEnergy	N/A	Utilizing a unique combination of gasification and fermentation processes, the facility will demonstrate key equipment at full commercial scale using vegetative, yard, and municipal solid waste as feedstock which will be heated to produce a synthesis gas that is cooled and cleaned before being fed to naturally occurring bacteria. These bacteria convert the synthesis gas into ethanol, which is purified for use as fuel in the transportation market. Current Status: Award Date: September 2010
Logos Technologies, Inc. Pilot CCM Biorefinery	Logos Technolgies, Inc., & EdiniQ, Inc.	N/A	Demonstrate advanced technologies and methods to convert non-food, cellulosic feedstocks into ethanol in an economically and environmentally compelling way. Current Status: Award Date: TBD
Myriant Succinic Acid Biorefinery (MySAB) Demonstration Facility	Myriant Technologies, Inc.	N/A	Facility will validate the production of succinic acid using proprietary, integrated, biocatalytic processes to displace petroleum based production of this plantform chemical. Produce succinic acid, an industrial organic chemical building block that can be used in the production of plymers, solvents and pigments. Current Status: Award Date: March, 2010
Demonstration of a Pilot, Fully Integrated Biorefinery for the Efficient Production of Clean, Synthetic Diesel Fuel from Biomass	Renewable Energy Institute International, Red Lion Bio-Energy, & Pacific Renewable Fuels	N/A	Demonstrate a pilot, pre-commercial integrated biorefinery for the production of high-quality synthetic diesel fuels from agriculture and forest residues using advanced thermochemical and catalytic conversion technologies. Current Status: Award Date: TBD
Sapphire Energy Integrated Algal Biorefinery (IABR)	Sapphire Energy Inc.	N/A	IABR will be built in Luna Country that will benefically reuse carbon dioxide to produce green crude oil from algae. The oil will be refined to produce jet fuel and diesel. Current Status: Award Date: TBD

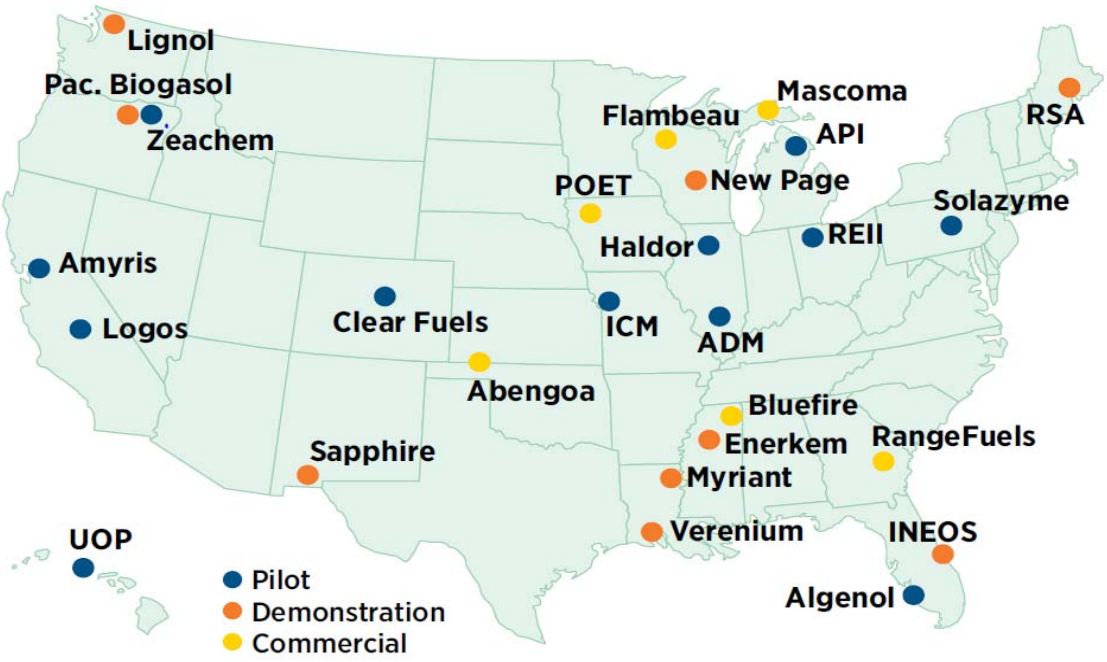
Project name	Lead Partner/ Project Period	Project cost	Project Description and Status
Solazyme Integrated Biorefinery: Diesel Fuels from Heterotrophic Algae	Solazyme, Inc.	NA	Demonstrate integrated scale-up of heterotrophic algal oil biomanufacturing process, validate the projected commecial-scale economics of producing multiple advanced biofuels, and collect the data necessary to complete design of the first commercial-scale facility. Demonstrate production of algal oil derived entirely from lignocellulosic feedstocks, as well as other feedstocks. Biofuels derived from these feedstocks will reduce lifecycle greenhouse gas emissions by over 90%. Current Status: Award Date: TBD
Sustainable Transport Fuels from Biomass and Algal Residues via Integrated Pyrolysis and Catalytic Hydroconversion	UOP, LLC	NA	A fully integrated process to convert high impact gasoline, diesel and jet range hydrocarbon. Feeds will be converted to fuels via integrated pyrolysis and hydro-conversion. Team members will demonstrate fungibility of the fuels within the refinery, determine fuel properties and accelerate qualification and acceptance as liquid transportation fuels. Current Status: ward Date: Early 2010
High-Yield Hybrid Cellulosic Ethanol Process Using High-Impact Feedstock for Commercialization by 2013	ZeaChem, Inc.	N/A	Biorefinery will convert 10 bone-dry tons per day of cellulosic feedstock into ethanol. A 95% reduction in life cycle greenhouse gas emissions for fuel production is anticipated in the commercial biorefineries as compared to conventional gasoline. Facility will use a hybrid of biochemical and thermochemical fractionation to separate the feedstock into a sugar-rich stream and a lignin-rich stream. The sugar stream is converted into acetic acid using naturally occurring bacteria, or acetogens, which produce no carbon dioxide during fermentation process and enabling 100% carbon conversion. Current Status: Award Date: TBD

Source:

U. S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, September 2011, http://www1.eere.energy.gov/biomass/factsheets.html

Websites of all companies serving as project leaders or key partners on the DOE funded projects.

Section: BIOREFINERIES
Integrated Biorefinery Project Locations



Source:
U.S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, November 2010.
http://www1.eere.energy.gov/biomass/pdfs/ibr_portfolio_overview.pdf

Section: BIOREFINERIES
Fuels, Technologies and Feedstocks in Planned Biorefineries as of 2008

Liquid Fuel Types Planned		
Ethanol	Propanol	Biogasoline
Methanol	Fischer-Tropsch diesel fuel	Lignocellulosic biodiesel
Bio-butanol	Renewable Crude Oil	Jet Fuel

Technologies Involved in Producton of Biofuels and Bioproducts	
Weak Acid Hydrolysis	Component of ethanol production, see BIOFUELS "The Ethanol Production Process - Dry Milling"
Enzymatic hydrolysis	Component of ethanol production, see BIOFUELS "The Ethanol Production Process - Dry Milling"
Engineered microbes	Component of ethanol production, see BIOFUELS "The Ethanol Production Process - Dry Milling"
Specialty enzymes	Component of ethanol production, see BIOFUELS "The Ethanol Production Process - Dry Milling"
Steam explosion hydrolysis	Alternative to weak acid hydrolysis for feedstock pretreatment
Strong acid hydrolysis	Alternative to weak acid hydrolysis for feedstock pretreatment
Hydrogenolysis process	One of several patent descriptions found at http://www.patentstorm.us/patents/4661643
Organosolv process	One of several patent descriptions found at http://www.patentgenius.com/patent/4470851.html
Fischer-Tropsch process	See http://wikipedia.org/wiki/Fischer-Tropsch for explanation
Gasification*	A thermochemical process creating a synthesis gas that can be transformed by catalysts or microbes to biofuels/bioproducts
Biomass Fractionation*	Separation of biomass components prior to pretreatment for a wide variety of possible end-products
Proprietary technologies*	Several proprietary technologies have been proposed

Feedstocks Planned for Production of New Biofuels and Bioproducts	
Agricultural Residues	**Industry and Municipal Residuals**
Citrus Waste	Municipal solid waste
Corn cobs, fiber and stover	Yellow/trap grease
Grain, rice and wheat straw	Construction waste
Leafy material	Urban wood waste
Energy Crops	**Other Woody Biomass**
Miscanthus	Hazardous forest fuels (thinning & slash)
Specially bred energy cane	Material from habitat restoration
Switchgrass	Logging and mill residues
Poplar, willow, and pine trees	

Source:
The information presented above is largely derived from the fact sheet on cellulosic biofuels developed in July 2008 by Justin Mattingly, Fahran Robb, and Jetta Wong of the Environmental and Energy Study Institute (www.eesi.org). Oak Ridge National Laboratory staff added links for additional information.

Note: More information can be found at:
http://www1.eere.energy.gov/biomass/factsheets.html

SECTION: BIOREFINERIES
Integrated Biorefinery Projects Receiving DOE Funds

Project	Location	Scale	Conversion Technology
Abengoa	Hugoton, KS	Commercial	Biochemical
Bluefire LLC	Fulton, MS	Commercial	Biochemical
Flambeau	Park Falls, WI	Commercial	Thermo - Gasification
Mascoma	Kinross, MI	Commercial	Biochemical
POET	Emmetsburg, IA	Commercial	Biochemical
Rangefuels	Soperton, GA	Commercial	Thermo - Gasification
Enerkem	Pontotoc, MS	Demonstration	Thermo - Gasification
INEOS New Planet Bioenergy LLC	Vero Beach, FL	Demonstration	Hybrid
Lignol	Washington	Demonstration	Biochemical
New Page	Wisconsin Rapids, WI	Demonstration	Thermo - Gasification
Pacific Ethanol	Boardman, OR	Demonstration	Biochemical
RSA	Old Town, ME	Demonstration	Biochemical
Sapphire Energy Inc.	Columbus, NM	Demonstration	Algae/CO2
Verenium	Jennings, LA	Demonstration	Biochemical
Myriant	Lake Providence, LA	Demonstration	Biochemical
Algenol Biofuels Inc	Fort Myers, FL	Pilot	Algae/CO2
American Process Inc.	Alpena, MI	Pilot	Biochemical
Amyris Biotechnologies Inc.	Emeryville, CA	Pilot	Biochemical
Archer Daniels Midland	Decatur, IL	Pilot	Biochemical
ClearFuels Technology	Commerce City, CO	Pilot	Thermo - Gasification
Haldor Topsoe Inc.	Des Plaines, IL	Pilot	Thermo - Gasification
ICM Inc.	St. Joseph, MO	Pilot	Biochemical
Logos Technologies	Visalia, CA	Pilot	Biochemical
Renewable Energy Institute International	Toledo, OH	Pilot	Thermo - Gasification
Solazyme Inc.	Riverside, PA	Pilot	Algae/Sugar
UOP LLC	Kapolei, HI	Pilot	Thermo - Pyrolysis
ZeaChem Inc.	Boardman, OR	Pilot	Hybrid

Source:
U.S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, November 2010.
http://www1.eere.energy.gov/biomass/pdfs/ibr_portfolio_overview.pdf

Below are nine projects relevant to the development of biorefinery technologies that were initiated during the 2000 to 2003 time frame by the U.S. Department of Energy. All projects have ended, some of the project partners are now involved in new biorefinery projects, while others have abandoned their efforts in this area.

Section: BIOREFINERIES

Recently Completed U.S. Department of Energy Biorefinery Projects

Project name	Lead Partner/ Project Period	Project cost	Project Description and Status
Making Industrial Biorefining Happen	Cargill-Dow LLC FY 2003-2007	$26 million	Develop and build a pilot-scale biorefinery that produces sugars and chemicals such as lactic acid and ethanol from grain. Current Status: Cargill Dow LLC is now known as NatureWorks LLC following Cargill's acquisition of The Dow Chemical Companies interest in the venture. The NatureWorks LLC website suggests that all products are currently made from corn starch.
Integrated Corn-Based Biorefinery	E.I. du Pont de Nemours & Co., Inc. FY 2003-2007	$18.2 million	Development of a biorefinery concept that converts both starch (such as corn) and lignocellulose (such as corn stover) to fermentable sugars for production of value added chemicals (like 1,3 propanediol) and fuel ethanol. Current status. Du Pont is making major investments in bioenergy technologies. The chemical 1,3 propanediol is now being commercial produced at DuPont Tate & Lyle Bio Products, LLC. in Loudon, Tennessee. DuPont and Genencor formed a joint venture company, DuPont Danisco Cellulosic Ethanol LLC, in May 2008 and this company is now the lead partner on the biorefinery project in Vonore, TN.
Advancing Biorefining of Distillers' Grain and Corn Stover Blends: Pre-Commercialization of a Biomass-Derived Process Technology	Abengoa Bioenergy Corporation FY 2003-2007	$17.7 million	Develop a process for pretreating a blend of distillers' grain (animal feed co-product from corn ethanol production) and stover to allow ethanol production from both, while leaving a high-protein animal feed. A large-scale pilot facility will be built for integration with High Plains' ethanol plant in York, Nebraska.
Big Island Demonstration project - Black Liquor	Georgia Pacific FY 2000 - 2007	NA	The project involved the design and operation of a black liquor gasifier that was to be integrated into Georgia-Pacific's Big Island facility in Virginia. This project anticipated helping pulp and paper mills with the replacement of recovery boilers that are reaching retirement. Current Status: The gasifier was built but the design did not function as anticipated and no current information can be located regarding any further work on the gasifier.
Collection, Commercial Processing, and Utilization of Corn Stover/Making Industrial Biorefining	Cargill-Dow LLC FY 2003-2007	NA	Develop new technologies that assist in the harvesting, transport, storage, and separation of corn residues. Engineer a fermentation system that will meet the performance targets for the commercial manufacture of lactic acid and ethanol from corn stover. Current Status: See description above.
Enhancement of Co-Products from Bioconversion of Muncipal Solid Waste	Masada OxyNol, LLC FY 2001 - 2004	NA	The unit operations of the Masada OxyNol™ process were to be examined and research focused on improving conversion efficiencies, mitigating scale-up risks, and improving the co-product quality and marketability. Current Status: The company now called Pencor-Masada Oxynol signed an agreement in 2004 with the city of Middletown, New York to build a waste-to-ethanol plant with a projected completion date in 2008. As of December 2007 the company was still trying to attract investors. The companies website still indicates that the project is proceeding, though the city has taken the company to court for failing to meet deadlines.
A New Biorefinery Platform Intermediate	Cargill, Inc. FY 2003 - 2007	$6 million	Develop fermentative organisms and processes to ferment carbohydrates to 3-hydroxypropionic acid (3-HP) and then make a slate of products from the 3-HP. Current Status: Cargill does make ethanol from corn starch at multiple locations. Their website suggests that the only current involvement in cellulosic ethanol is the funding provided to Iowa State University that includes money for an economic analysis of corn stover production, harvest, handling and storage.
A Second Generation Dry Mill Biorefinery	Broin and Associates FY 2003 - 2007	$5.4 million	Separate bran, germ, and endosperm from corn kernels prior to making ethanol from the remaining starch. Investigate making high-value products, as well as ethanol and animal feed from the separated fractions. Current Status: Broin and Associates, now called POET, is pursuing "Project Liberty", a project that is constructing a cellulosic ethanol production stream at their Scotland N.D. corn to ethanol facility. This project was awarded DOE funding in February 2007 and corn cobs were harvested in 2007 as feedstock for the facility.
Separation of Corn Fiber and Conversion to Fuels and Chemicals Phase II: Pilot-Scale Operation	National Corn Growers Association FY 2003 - 2007	$2.4 million	Under a previous DOE-funded project, a process was developed for separation of hemicellulose, protein, and oil from corn fiber. This project will pilot-scale test and validate this process for commercial use. Current Status: ADM a partner in the NCGA project announced in August 2008 that it was partnering with John Deere to harvest,

Sources:

U. S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, October, 2011, http://www1.eere.energy.gov/biomass/factsheets.html

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