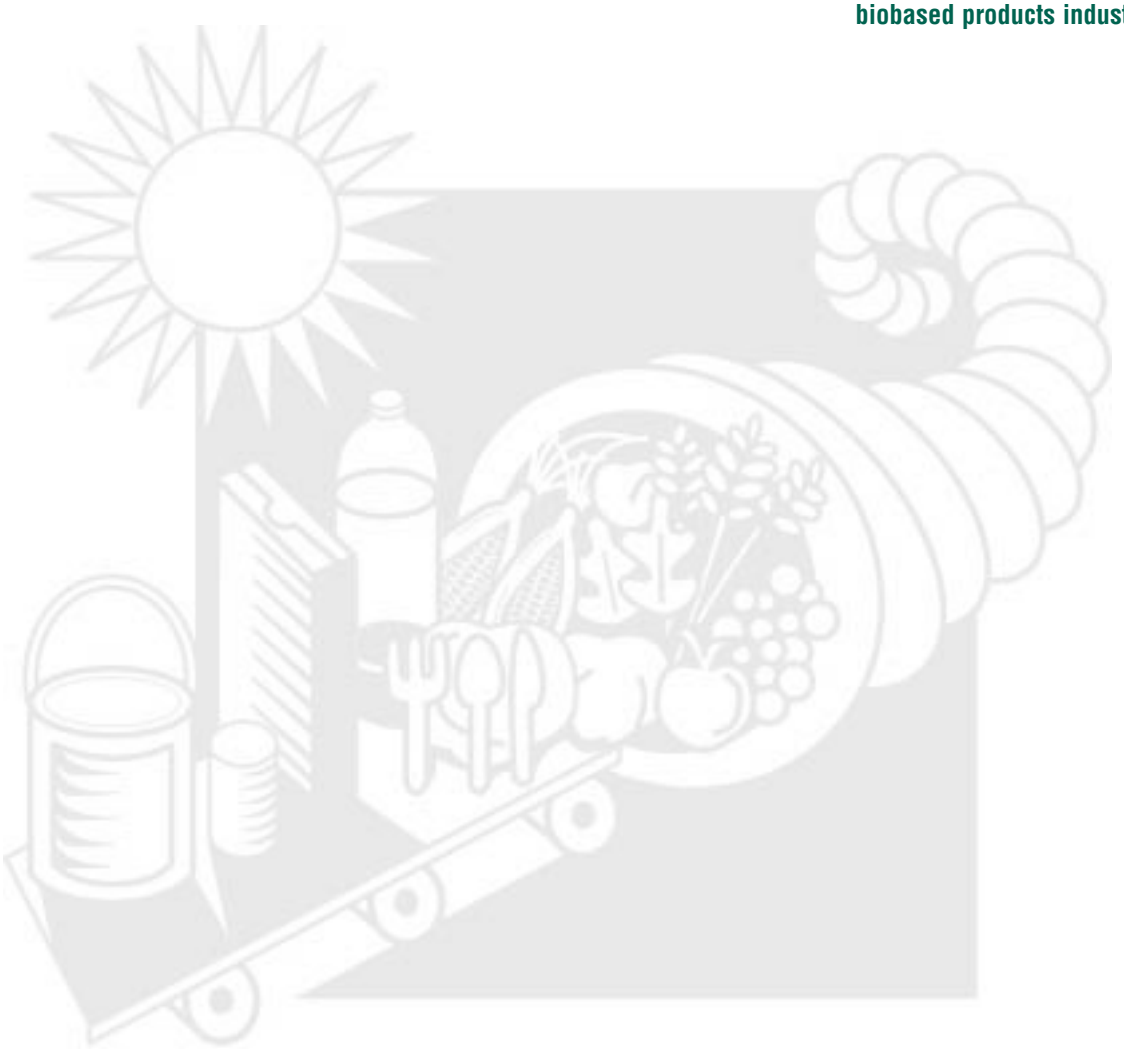
agriculture

Agriculture — Industry of the Future

Accelerating the growth of the emerging biobased products industry



Office of Industrial Technologies

Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

Why work together?

Expanded industrial use of plant-derived renewable resources will require a multidisciplinary, integrated approach. By working with the Office of Industrial Technologies, the biobased products industry gains:

- *A powerful common voice*
- *Clear definition of high-priority research needs*
- *Expanded R&D resources*
- *Increased collaboration among researchers, including national laboratories*
- *Interrelated research projects conducted in a parallel and coordinated manner*
- *Cleaner, more energy-efficient technologies and processes*

partnership

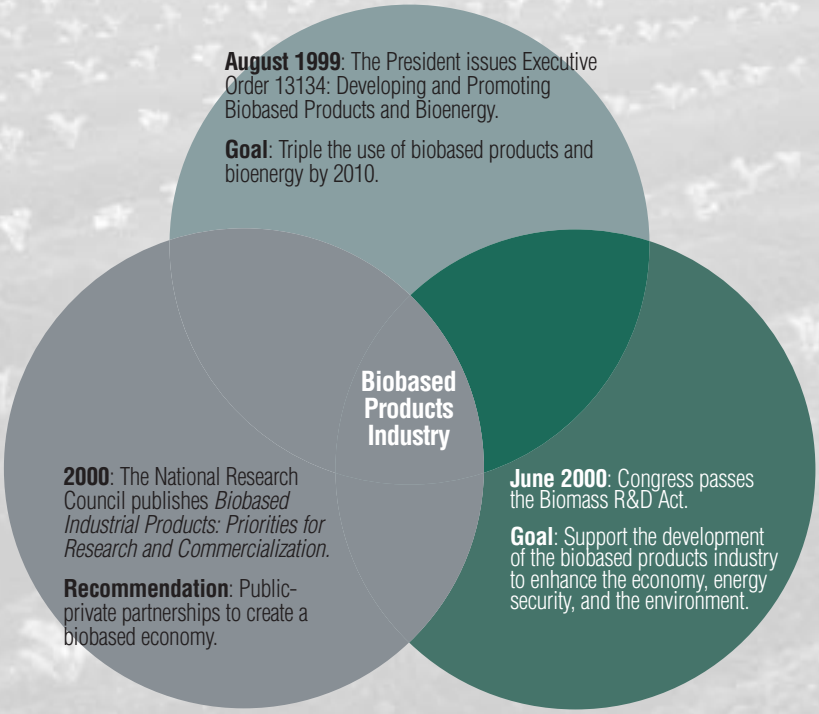
Building an industry

The emerging biobased products industry uses crops, trees, residues, and wastes to produce chemicals and materials such as plastics, paints, and adhesives. Growth of this industry will facilitate use of plant and crop-based renewable resources to supplement fossil-based resources and will help serve national goals for energy and the environment.

Expanding the use of biobased products as industrial feedstocks will require extensive multidisciplinary research and the development of cost-effective technologies and processes. Manufacturers and growers have entered into a partnership with the U.S. Department of Energy's Office of Industrial Technologies (OIT) to foster the necessary educational initiatives and pursue the needed technology research and development (R&D). Known as the Agriculture Industry of the Future, the partnership seeks to substantially increase the use of plant-derived renewables as basic chemical building blocks—from 3 percent of chemical feedstocks today to 10 percent by 2020.

Growing Momentum

The executive and legislative branches and scientific experts have come together in support of the biobased products industry.



Benefits to rural communities and the nation:

- *New jobs, investments, and businesses*
- *A cleaner, healthier environment*

Industry leads the way

Through the Industries of the Future partnership, the biobased products industry has taken the lead in defining its own technology needs. The partnership created a vision and technology roadmap, defining the industry's common goals and priorities. It is now implementing the roadmap.

Vision

The Plant/Crop-Based Renewable Resources Vision 2020, initiated by the National Corn Growers Association in 1996, defines the 20-year vision for the industry. In February 1998 industry and grower representatives signed a compact with DOE and USDA to work together to support this new industry. A coalition of industry and grower groups then established an Executive Steering Group to identify the priority research areas for the biobased products industry.

Roadmap

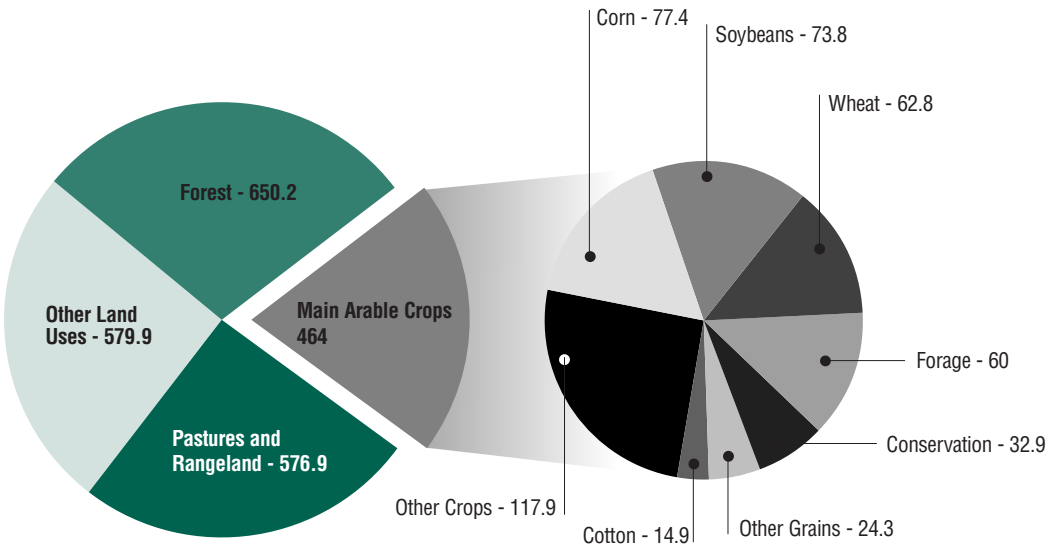
The Plant/Crop-Based Renewable Resources Roadmap was developed in 1998 by over 100 representatives from the agriculture, chemicals, and forestry communities. The roadmap defined priority R&D needs; established specific technology strategies; and laid out a logical, prioritized sequence of R&D, including key milestones and performance targets.

Implementation

Fiscal year 1999 marked the first year of funding for OIT's Agriculture Team. Through a competitive solicitation, six R&D projects were selected and are currently under way. In fiscal year 2000, six new education grants and six new R&D projects were selected. (See pages 4 and 5.)

U.S. Land Area of Plant/Crop-Based Resources for the Biobased Products Industry

In millions of acres



Sources: Department of Commerce, Statistical Abstracts 1999; USDA, Agricultural Statistics Survey.

Boosting industry performance

results

Using a competitive review process based on industry-defined priorities, OIT awards funds to projects that will increase use of renewable resources and improve the cost-competitiveness of biobased products. Collaborative teams from industry, universities, growers, national laboratories, and other organizations share the cost and risks of R&D. The Agriculture Team has six R&D projects currently under way (described in the chart below.)

In fiscal year 2000, six additional new R&D projects were selected:

- Clean Fractionation for the Production of Cellulose Plastics
- Novel Membrane and Fractal Separation Systems
- Development of Yeast for the Fermentation of Agricultural Feedstocks to Chemicals
- Vegetable Oils as Polymer Building Blocks
- 1,3-Propanediol Via Fermentation-Derived Malonic Acid
- Continuous Isosorbide Production Using Solid Acid Catalysts

In addition, the Agriculture Team conducted the first annual solicitation for education projects in fiscal year 2000, with awards going to the Colorado School of Mines, Iowa State University, Michigan State University, Oklahoma State University-Stillwater, University of Georgia, and University of Nebraska-Lincoln. These projects stem from an initiative—launched by OIT in 1999 at the annual meeting of the National Association of State Universities and Land-Grant Colleges—to promote the establishment of multidisciplinary graduate-level education and research programs that will support the emerging biobased products industry.

While the team is still young, it can already point to two success stories: Clean Fractionation and Polylactide Polymers (see insets).

*Visit **www.oit.doe.gov/agriculture** to learn more about the projects in OIT's agriculture portfolio.*

Clean Fractionation

Clean Fractionation technology, originally funded by the OIT Chemical Team, has been highly successful in separating cellulose from wood fiber. An energy-efficient alternative to traditional wood pulping, Clean Fractionation yields more highly purified cellulose that can be used to produce rayon, acetate fibers, and other thermoplastics. The technology may also serve as an enabling technology for the use of biomass in many other chemical products.

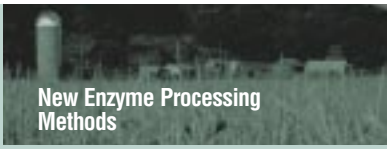
Current Agriculture Team Projects

Commodity Chemicals from Glucose

The project partners will use new catalysts to develop processes to convert corn-derived glucose to chemicals such as sorbitol, succinic acid, and lactic acid, providing an alternate feedstock for chemical production. These intermediate chemicals could then be converted to a variety of end products, such as propylene glycol and ethylene glycol.

- Reduces dependence on petroleum feedstocks
- Catalyst technology will be applicable to other biobased products

Partners: National Corn Growers Association, Michigan State University, Pacific Northwest National Laboratory



New Enzyme Processing Methods

Using CLEC, a technology developed by Altus Biologics, researchers will develop a form of glucose isomerase enzyme able to withstand higher operating temperatures while converting glucose to fructose. As a result, the fructose/glucose ration will increase, thereby decreasing the need for downstream separations and recycling. This technology can be extended in the future to enable the efficient production of chemicals and materials from renewable biobased resources.

- Eliminates energy-intensive fractionation and evaporation steps
- Extends enzymes activity
- Enables the use of less costly glucose feedstock

Partners: Altus Biologics, Genencor, Cargill, Oak Ridge National Laboratory

From Corn to Plastics

On April 25, 2000, Cargill Dow broke ground in Blair, Nebraska, for the first large-scale polylactide (PLA) manufacturing plant in the world. DOE has helped catalyze the development of this technology for several years, awarding over $4 million in cost-shared funding to several PLA development projects. DOE Deputy Assistant Secretary Denise Swink was a keynote speaker at the groundbreaking ceremony.

The Cargill Dow plant will be the first facility to produce renewable resource-derived plastics able to compete with conventional petroleum-based polymers. The plant is expected to be fully operational by 2002, producing 300 million pounds of PLA a year.

Other Relevant R&D Projects

In addition to the projects directly funded by the Agriculture Team, here are a few of the many projects in progress in other parts of OIT and DOE from which the biobased products industry can benefit.

Chemicals

- Membrane Process for Lactate Esters
- Advanced Electrodeionization Technology for Product Purification, Waste Recovery, and Water Recycling

Forest Products

- Pine Gene Discovery Project
- Diagnosis of Soil Limitations to Productivity
- Nutrient Limitations in Intensively Managed Southern Pine
- Growth Traits in Pinus Taeda L.
- Molecular Physiology of Nitrogen Allocation in Poplar Trees

DOE Biorefinery

- Polylactic Acid, Ethanol, and Power
- Wood Adhesives Formulations from Bark-Derived Phenols
- Corn Fiber Separation and Subsequent Conversion to Fuels and Chemicals
- Production of Chemicals, Fuel, and Power from Hog Manure Using 2-Stage Anaerobic Digestion

Inventions and Innovation

- Energy Efficient Irrigation
- Anaerobic Pump

Small Business Innovation Research

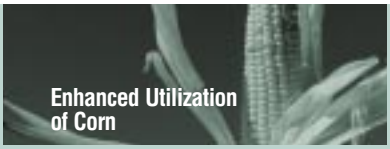
- Renewable Fine Chemicals
- Separation Process for Biobased Succinic Acid
- Production of Butyric Acid and Butanol from Biomass

Cooperative Programs with States

- High-Value Products from Wheat

NICE³ (National Industrial Competitiveness Through Energy, Environment, and Economics)

- Precision Irrigation for Agriculture



Enhanced Utilization of Corn

Project partners are examining the structure-physical/chemical property relationship of polylactic (PLA), a biodegradable plastic, in order to improve the processability of PLA. Ultimately, this will allow for new materials with improved properties, expanding the application of PLA.

- Utilizes renewable source as feedstock
- Reduces landfill volumes
- Removes greenhouse gases from atmosphere

Partners: Cargill Dow, National Renewable Energy Laboratory, Colorado School of Mines

Chemicals from Lignocellulose

Researchers are integrating two approaches to utilizing waste agricultural feedstocks by converting wood waste and rice straw to mixed sugars, fermenting the sugars to produce lactic acid, and chemically converting the acid to lactic esters. Lactic esters can serve as solvents or raw material for chemicals and polymers, replacing some petroleum-derived products.

- Expands the use of agricultural feedstocks
- Enhances national energy security
- Serves a $5 billion U.S. market

Partners: University of California-Davis, Argonne National Laboratory, BC International, NTEC-Versol

Soy-Based Engine Oils

About 15 million gallons of oil are consumed by the recreational boating sector in North America. Researchers want to develop, test, and screen a series of 2-cycle engine oils based on vegetable oils for use in water-cooled engines that will offer the same performance as petroleum-based products.

- Saves millions of gallons of petroleum annually
- Offers a 90% to 100% biodegradable product
- Produces fewer emissions
- Increases fire safety
- Extends engine life

Partners: Terresolve Technologies, Ltd.; United Soybean Board; Smith, Bucklin & Associates; Omni Tech International

Products from Wheat Milling

Researchers are developing processes to upgrade the value of the mill feed by-product currently used as animal feed. Recovered starch is valuable itself and can provide an energy-efficient feedstock for chemicals such as sugar alcohols and polyols, and for use in antifreeze and other products. The remaining mill feed has a higher protein content and greater value as animal feed.

- Decreases emissions of greenhouse gases, particulates, and VOCs
- Replaces petroleum as the feedstock for chemicals
- Significantly reduces the amount of electricity and petroleum in processing

Partners: Pendleton Flour Mill, Inc., Mennel Milling Company, Pacific Northwest National Laboratory

Coordinated assistance for today and tomorrow

resources

Each year, the OIT Agriculture Team awards cost-shared funds to new projects that benefit the biobased products industry. OIT's Agriculture Team supplements its own R&D budget by coordinating activities with other OIT and federal programs that can help advance industry goals.

Other OIT programs of value to the biobased products industry include research and development of **Enabling Technologies**, **BestPractices** initiatives, and **Financial Assistance**.

In response to the Biomass R&D Act of 2000, the Agriculture Team has also forged new links to programs elsewhere in the Office of Energy Efficiency and Renewable Energy, the Office of Science, USDA, and other executive branch agencies.

Enabling Technologies

OIT works with industry, the national laboratories, academia, and others to research, develop, and commercialize enabling technologies that can benefit a wide range of industries, including agriculture. The **Advanced Industrial Materials** program focuses on new or improved materials, such as polymers, to enhance product quality and energy efficiency. Research in **Sensors and Controls** strives to develop integrated measurement systems for operator-independent control of processes.

Energy and waste assessment of Pendleton Flour Mill

An industrial assessment performed at the Pendleton Flour Mill in Pendleton, Oregon, identified several motor and motor-related areas that have the potential to save millions of Btu per year. Upgrading to more efficient motor and motor components could save money and reduce energy costs.

BestPractices

Through the BestPractices program OIT helps manufacturers apply existing technologies to save money, cut emissions, and reduce wastes. OIT alerts companies to opportunities for funding, tools, expertise, and potentially applicable technologies in OIT's extensive portfolio of crosscutting products and services. The returns for industry can be significant.

Plant-wide assessments are also offered by BestPractices, helping manufacturers develop a comprehensive strategy to increase efficiency, reduce emissions, and boost productivity. Up to $100,000 in matching funds is awarded for each assessment through a competitive solicitation process. Participants agree to a case study follow-up of results. Alternatively, small to mid-sized manufacturers can take advantage of the **Industrial Assessment Centers** program, which provides no-charge assessments through a network of engineering universities.

Financial Assistance

Two financial assistance programs are offered by OIT to accelerate technology development and application. The **Inventions and Innovation** program awards grants up to $200,000 to inventors of energy-efficient technologies. Grants are used to establish technical performance, conduct early development, and initiate commercialization activities. The second program, **NICE^3** (National Industrial Competitiveness through Energy, Environment, and Economics), provides cost-shared grants of up to $500,000 to industry-state partnerships for demonstrations of clean and energy-efficient technologies. A technology demonstration funded by the NICE^3 program was one of the early projects to biologically convert biomass waste to chemicals.

State-Level Industries of the Future

In addition, State-Level Industries of the Future programs are starting up in a number of states to bring the energy, environmental, and economic benefits of industrial partnerships to the local level.

For more information on these and other resources, please contact the OIT Clearinghouse at (800) 862-2086.

How to get involved

Through Industries of the Future partnerships, the nascent U.S. biobased products industry reaps the competitive advantages of more efficient and productive technologies and, in turn, contributes to our nation's energy efficiency and environmental quality.

To participate:

- *Monitor the OIT Agriculture Team's Web site for news and announcements of R&D solicitations, meetings and conferences, and research projects (www.oit.doe.gov/agriculture).*
- *Team with other organizations and respond to solicitations for cost-shared research.*
- *Begin saving energy, reducing costs, and cutting pollution today by participating in any of the BestPractices programs.*
- *Take advantage of OIT's extensive information resources, including fact sheets and case studies, training, software decision tools, technical advice on systems, searchable CDs containing project data and publications, The OIT Times newsletter, and a publications catalog.*
- *Sponsor and/or attend the biennial Industrial Energy Efficiency Symposium and Expo.*
- *Encourage your state to establish a State-Level Industries of the Future team.*
- *Apply for the Education Initiative and develop a graduate program promoting multidisciplinary education in the biobased products industry.*
- *Hold or attend a showcase demonstration to see the technological benefits of industry/OIT partnerships.*

www.oit.doe.gov/agriculture

For more information on the Agriculture Industry of the Future,
contact the OIT Clearinghouse at (800) 862-2086
or visit www.oit.doe.gov/agriculture

Please send any comments, questions, or suggestions to webmaster.oit@ee.doe.gov

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