Federal Programs Help Develop Biobased Industrial Uses

U.S. agriculture likely will have substantial excess capacity for the foreseeable future. However, technological breakthroughs, heightened environmental awareness, and tougher environmental regulations are creating opportunities to use this capacity to produce industrial products. A host of Federal programs are working to help the private sector take advantage of these opportunities.

In recent years, 15 to 20 percent of U.S. cropland is idled annually by Federal farm programs. At present, much of this land is tied up in the Conservation Reserve Program (CRP) and in rebuilding supplies from the effects of this year's poor harvest. But as supplies are restored and CRP ends, the long-term capacity dilemma will reassert itself. This dilemma involves both agriculture's natural resource endowment and productivity growth relative to demand.

The United States has a well developed land base, with over 340 million acres being cropped on a regular basis and another 30 to 40 million acres readily available for conversion from less intensive uses, such as pasture, to intensive cropping. The total number of arable acres has changed little over time.

Productivity growth, 1.5 to 2 percent annually, exceeds increases in domestic demand for farm products associated with income and population growth, possibly 1 to 1.5 percent per year. Without other sources of demand growth, excess capacity may grow and resources will leave agriculture.

Rising exports are one source of demand growth. The North American Free Trade Agreement, the General Agreement on Tariffs and Trade, and U.S. export programs are important efforts to boost demand through improving access to foreign markets. These offer the largest immediate gains in demand for U.S. agricultural products.

Over the long run, however, new uses for agricultural products also promise to expand both domestic and foreign demand for U.S. agriculture goods. Industry has developed some products from agricultural and forestry materials he., biobased feedstocks) over the years, but until recently successes have been few, mainly due to a lack of adequate cost-effective technology. Fortunately, there have been major advances in metabolic engineering, advanced fermentation, reactor development, and separations technology that were not available as recently as 5 years ago. These advances are creating new opportunities.

Industrial Uses Receive Attention at USDA

New opportunities for biobased products have received increased attention at USDA. Many agencies are involved. USDA's Office of Energy and Economic Research Service, together with the Colorado School of Mines, have initiated a major study to determine emission effects of ethanol-blended fuels.

The newly created Alternative Agricultural Research and Commercialization (AARC) Center is now helping a number of public-private ventures bridge the gap between research and commercialization of biobased industrial products. Unique to the AARC Center is a provision for repayment by successful projects. Repayment is typically linked to product sales, so if sales are slow, a firm not strapped for cash in order to meet its repayment obligation.

In its first call for suggested partnerships, the AARC Center received more than 400 preproposals requesting $175 million. While many of the applicants were considered worthy, the AARC Board had less than $10 million to invest, which limited the number of projects it could support. The funded projects include:

- Ethanol from grasses and other biomass sources--three projects in California, Florida, and Texas;
- Paper pulp from straw--Oregon;
- Newsprint from kenaf and recycled fibers--Texas;
- Lawn mats from kenaf--California;
- Structural composites from kenaf--California;
- Furniture parts molded from flaked low-grade lumber--Michigan;

  A granite-like composite board for furniture, tile, and structural use from soybeans and waste newspaper--Minnesota;
- On-farm composting utilizing animal manure, animal bedding, yard waste, and starch-based biodegradable polymers--Pennsylvania;
- Biodegradable films and coatings from wheat starch--Kansas;
- Cornstarch-encapsulated pesticides--two projects in Kansas and Missouri;
- Nontoxic ethanol-based windshield washer fluid--Missouri;
- Three biodiesel projects: production and processing technology in Kansas, production from animal by-products in Florida, and performance standards in Washington, DC;

- Biodegradable lubricants from crambe and industrial rapeseed oils--Washington;
- Biodegradable concrete-release agents from canola and industrial rapeseed oils--Illinois;
- High-value industrial chemicals from corn--Washington;
- Industrial booms, pads, socks, and other items to clean-up chemical spills from low-grade wool--Texas;
- Biodegradable specialty lubricants and cosmetics from lesquerella oil--California/Arizona; and
- Insulation material using milkweed floss--Nebraska.

The third program is being sponsored by USDA's Agricultural Research Service (ARS). ARS strongly encourages its scientists to enter into Cooperative Research and Development Agreements (CRADA7s)with private f m s in order to commercialize technology based on their research. These agreements provide the cooperator with the right of first refusal to an exclusive license on patented inventions made under the project. Since the CRADA system was first established in 1986, ARS and the Department of Energy (DOE) have implemented over 800 agreements. Over the last 4 years, ARS has accounted for over 60 percent of USDA expenditures on new uses.

ARS also helped establish the Biotechnology Research and Development Corporation (BRDC). BRDC is a consortium involving ARS, the University of Illinois Biotechnology Center, and seven stockholders; Agricultural Research and Development Corp., American Cyanamid, Amoco Technology Co., The Dow Chemical Co., Allexion, Inc., Hewlett-Packard Co., and IMCERA. The consortium defines research projects that have market potential and enables industry to enter into high-risk ventures that might otherwise be too risky for a single firm to undertake.

BRDC has licensed ARS patents to encapsulate pesticides within a starch matrix. The resulting granule not only protects the active ingredient from deterioration due to handling or storage, but also provides for controlled release when the pesticide is applied. BRDC and four of its shareholders--American Cyanamid, Dow Chemical, ECOGEN, and Pitman-Moore--are investing $475,000 in the new encapsulation process and the AARC Center is investing an additional $500,000.

USDA's Cooperative State Research Service (CSRS), Office of Agricultural Materials, also sponsors biobased activities. Their mission is to foster the development and commercialization of industrial products and processes for the value-added utilization of agricultural raw materials. The Office of Agricultural Materials works with, and funds, university teams to develop processes to manufacture biobased industrial products. Two product-oriented consortia have been formed with non-Federal sources to leverage Federal investments. One is the High Erucic Acid Development Effort (HEADE), consisting of nine States and ARS. HEADE's goal is to assist the development and commercial production of industrial rapeseed and crarnbe, crops high in emcic acid. The other is a consortium to develop technologies to produce natural rubber and other products from guayule.

CSRS also collaborates with the Department of Defense. In fiscal year 1993, 40 projects were funded under the Advanced Materials From Renewable Resources and the Biodegradable Packaging Programs, including:

- Functional fluids--made from rapeseed, crambe, castor, lesquerella, and jojoba oils;
- Oil-selective adsorbents--many plant materials, including kenaf, have a natural affinity for oils and can be used as oil-absorbent pillows and booms and in food processing equipment;
- Vegetable oil epoxies--naturally occumng fatty acids in many plants can be converted to epoxies for use in high-temperature polymers and adhesives, biodegradable adhesives, paints, and coatings;
- Nylon--development of high performance nylons based on agricultural products;
- Biodiesel fuels--facilitation of biodiesel use in selected niche markets;
- Natural biocides and biocidal coatings--several natural sources of biocidal materials from present and new crops are being investigated; and
- Biodegradable polymers from starch--the goal is to provide the Navy with biodegradable eating utensils and packaging materials for use aboard ships. This will help them comply with the MARPOL Treaty which requires, beginning in **1994,** that all materials disposed of at sea be biodegradable.

DOE, NRC, and EPA Also Sponsor Activities

Biomass conversion and utilization research within DOE **are** centered in the Office of Transportation Technologies (O W , the Ofice of Utility Technologies (OUT), and the Office of Industrial Technologies (OIT). OTT focuses on the **produc-** tion of biofuels, such as ethanol and biocllesel from lignocellulosic feedstocks. OUT concentrates on biomass utilization for electricity generation. OIT focuses on the production of non-fuel related chemicals, such as organic acids and solvents.

One of DOE'S most ambitious efforts is the Alternative Feedstocks Program (AFP). AFP recognizes that worldwide use of biomass for food, feed, and fiber accounts for only 7 percent of total biomass production--a tremendous untapped source of energy. Therefore, this program is targeted at developing processes to produce high-volume chemicals from renewable resources. **AFP** is working with the agricultural and forestry industries and the research community to develop high-volume chemicals used to manufacture value-added products.

Environmental considerations should increase the demand for renewable resources. For example, key international companies and industrial organizations recently met in Rotterdam to endorse a set of principles and a charter that will commit them to environmental protection into the 21st century. Also, the 1992 Earth Summit emphasized the need for developing partnerships between countries, industries, and governments to establish a stewardship over the planet's resources and environment.

Moreover, environmental legislation is increasing the costs of traditional processes and, consequently, boosting the attractiveness of biobased alternatives. The Chemical Manufacturer's Association estimated that in 1990, capital expenditures by the chemical industry for pollution abatement amounted to $1.68 billion and associated annualized operating expenditures were about $3.83 billion ***(1)***. Needless to say, these capital investments coupled with administering applicable laws and regulations have increased product prices. Furthermore, there will likely be efforts to pass tougher environmental legislation.

Given these opportunities, the objective of **AFP** is to develop bio-processes that:

- Enhance profitability and competitiveness of U.S. industry,
- Give significant savings of energy and imported oil over present technology, and
- Serve environmental goals to reduce emissions of greenhouse gases and discharges of hazardous waste.

An initial technical and economic assessment of project opportunities was recently completed through a joint collaboration of five DOE national laboratories and an industry panel. Several USDA scientists and managers contributed to the assessment and are providing suggestions on future analyses. Through various partnerships with industry, AFT will develop biobased processes for large-scale industrial production of high-volume intermediate chemicals. Partnership opportunities include industry solicitations and CRADA's between firms and DOE researchers.

AFP's first report is entitled ***The Alterative Feedstocks Program--Technical and Economic Assessment.*** It contains quantitative, comparative, and process analyses and an economic evaluation of the potential costs and benefits of making 70 chemical products from renewable resources. The report also suggests how these products will be incorporated into the chemical industry.

Another objective of AFP is to demonstrate through industry partnerships the commercial feasibility of biobased processes. AFP managers recommend that two processes be added each year, resulting in a total of 12 under development by the year 2000. Ongoing assessments and program reviews will determine future targets--those technologies of investment grade quality.

Classes of products that could have the biggest potential impact on commodity chemical production were chosen and specific examples for further development within each class were considered. For example:

- Organic acids--succinic acid will be processed from corn syrups, which provides an opportunity to demonstrate the feasibility of producing a commodity chemical from renewable resources, and
- Cellulosic materials--the clean fractionation of biomass is a process being developed that allows separating lignocellulosic material into its three primary components--cellulose, hemicellulose, and lignin--more cleanly than current technologies.

A complementary program within OIT is the Biological and Chemical Technologies Research Program. This applied research and development program provides enabling technology for new industrial chemical and biological processes. A primary focus of the research is to resolve process limitations in converting renewable resources to chemical feedstocks.

The National Research Council W C) has recently begun an analysis of biobased industrial materials. NRC believes the lack of a realistic assessment of key research areas and their commercial viability is preventing the adoption and utilization of many biobased technologies. So, NRC has assembled a committee of experts to address key aspects of researching and commercializing biobased products. The committee is preparing a report designed to provide guidance for future actions by government, industry, and academia. The major sponsors of this study include DOE, USDA, and the National Science Foundation.

In addition, USDA, DOE, and the Environmental Protection Agency entered into a memorandum of understanding in October to establish the AgSTAR program. AgSTAR, a voluntary program, encourages the widespread use of methane recovery technologies to increase livestock producers' profits and demonstrate that industrial and environmental interests can work together to achieve common goals. AgSTAR participants will be able to cut their energy bills and get extra income from manure byproducts. The program will establish demonstration projects, work on improving technology transfer, and facilitate workable financial packages for participants.

To recap, there are a host of Federal efforts to develop biobased industrial products. The goal is to create demand-driven needs for farm-based industrial products that will enhance the profitability and competitiveness of U.S. agriculture and industry, save energy and cut use of imported oil, and serve environmental goals. Douglas Beach and Gregory Gajewski (202) 219-0085]

1. Bozell, Joseph J. and Ron Landucii, editors. ***The Alternative Feedstocks Program: Technical and Economic Assessment.*** Prepared for the U.S. Department of Energy, Office of Industrial Technologies by Argonne National Laboratory, Idaho National Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory, July 1993.