DEVELOPING U. S. BIOMASS RESOURCES:

PUBLIC SECTOR SUPPORT AND PRIVATE SECTOR OPPORTUNITIES

by

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Presented To The

11th ANNUAL WORLD FOOD AND AGRIBUSINESS FORUM AND SYMPOSIUM
of the
INTERNATIONAL FOOD AND AGRIBUSINESS MANAGEMENT ASSOCIATION

meeting in

SYDNEY, AUSTRALIA

June 25 - 28, 2001

*The views expressed in this paper are solely those of the author and do not represent policy positions or official/unofficial views of the United States Department of Agriculture and its Offices and Agencies or of the United States Government.

Introduction

Interest within the Federal government and in the private sector continues to grow over what are perceived as attractive opportunities to deploy bioproducts and bioenergy in a growing array of applications. This interest is reflected in a National Research Council Report, published in 2000, that begins with the confident statement, "Biological sciences are likely to make the same impact on the formation of new industries in the next century as the physical and chemical sciences have had on industrial development throughout the century now coming to a close."(1)

A similar theme resonates in the *National Energy Policy*, a recently released report by the President's National Energy Policy Development Group, "These non-depletable sources of energy are domestically abundant and often have less impact on the environment than conventional sources. They can provide a reliable source of energy at a stable price, and they can also generate income for farmers, land owners, and others who harness them."(2)

Secretary of Agriculture Ann M. Veneman, also voiced strong support for bioproducts and bioenergy research and development in prepared remarks to the U. S. Department of Agriculture (USDA) Outlook Conference in February, 2001, when she declared, "In order for the U.S. agricultural economy to remain competitive, we need to accelerate our search for innovative uses for farm products. Energy is a prime example. The nation needs new sources of clean, dependable energy and agriculture needs new markets - a coincidence of needs upon which we should capitalize. Research into biomass technology could develop efficient fuels and other chemicals from virtually any plant or plant product. We should step up development of new technologies for cost-effectively producing important fuels like ethanol, bio-diesel and other bioproducts that not only provide markets for products but have environmental benefits as well." (3)

Drivers For New Emphasis On Bioproducts And Bioenergy

A number of drivers are spurring the new emphasis on developing the biobased economy. First, increased discipline by OPEC members has resulted in markedly higher crude oil prices, worldwide, than during the late 1990s. For a number of years in the 1990s, world crude oil prices ranged in a low to upper teens in dollars per barrel. Prices at that level discouraged new exploration, especially in the U. S. and in the more expensive off-shore development. Low prices and rising demand proved to be the catalysts that restored OPEC member discipline. Economic growth in developing countries has added to oil demand, reducing excess capacity of Middle East oil producing countries. Rapid population growth in the same countries has increased the demand for oil revenues to support rising expectations of their young citizens. In the past two years, OPEC has successfully managed crude oil supplies, holding prices close to their target range. The *Oil and Gas Journal* reported the OPEC basket-price for oil at $23.47 for April 6, 2001.(4)

Second, there is growing awareness and concern about U. S. energy security.

Senator Richard G. Lugar (Indiana) and R. James Woolsey (formerly director of the Central Intelligence Agency) writing in *Foreign Affairs* argue that, "U. S. dependence on imported oil keeps U. S. military forces tied to the Persian Gulf, forces foreign policy compromises, and sinks many developing nations into staggering debt ..... In addition, oil causes environmental conflict."(5) The authors go on to suggest that ethanol provides a reasonable alternative to imported oil.

Third, low farm commodity prices have caused farm interest groups to seek new uses - new market opportunities for agricultural products. Two factors have converged in recent years to create greater interest in biobased products and bioenergy among agricultural producers and policy makers. U. S. and world crop production has remained quite large, limiting the opportunities for commodity price strength. In addition it has proven difficult to increase U. S. agricultural export sales from the current low $50 billion range back to $60.5 billion level of 1996.

Because of low commodity prices, the U. S. Congress has passed several emergency assistance packages for U. S. farmers in recent years. These assistance packages have ratcheted up in cost as policy makers sought to place a safety net under net farm income. Farmers received an annual average of $8.8 billion in direct payments during the 1990-97 period. The annual average for direct payments had risen to $17.3 billion for 1998-2001. In 2000, direct government payments to farmers reached a new high of $22.1 billion. While net cash farm income of $56.4 billion in 2000 was the fourth highest on record, direct government payments to farmers equaled 39 percent of that income.(6)

The high cost of income support assistance to farmers and the growing likelihood that many farm commodity prices will stay relatively low for the foreseeable future is driving a search for policy alternatives. It is hoped policies can become more successful in improving farm commodity prices and in helping the farm sector achieve profitability in a more market oriented policy environment.

There is growing interest in developing new markets for biobased products and bioenergy. These markets could create substantial new demand for farm commodities and could underpin economic growth in rural communities with new bioproducts processing plants and biomass fired electric power generation facilities.

Policy analysts and policy makers are beginning to ask whether a substantial public sector investment, over a decade long period, in biobased product and bioenergy research and development, including commercialization, could provide a larger and more lasting increase in farm product prices, net farm income and re-invigoration of rural communities, than the cycle of rising government emergency payments to farmers has been able to accomplish. That investment in biobased activities, accompanied by supportive public policy, would improve the cost effectiveness of these products, create increased commercial market demand for them and that, in turn, would set the stage for market driven improvements in farmer well-being and rural community vitality.

Fourth, in the United States, there is a growing sense that global warming is at least partially the result of human activity. Thoughtful people are discussing ways in which U. S. GDP growth can be

achieved with a diminished environmental footprint. An important part of the solution is found in developing biobased products and bioenergy as alternatives to fossil fuel based sources. This will result in recycling of carbon that is released into the atmosphere, limiting future release and buildup of carbon.

A final factor affecting the renewed interest in biobased products and bioenergy is the current and prospective state of biological sciences. By most evaluations, plant science (including genetics, cellular biology, plant breeding and production) is poised on the threshold of an historically productive period that will lead to breeding, producing, and processing of plants with specialized attributes for use in products that substitute for fossil based fuels, industrial chemicals and pharmaceuticals. Improvements in conversion efficiency and cost effectiveness of biobased products and bioenergy are both necessary to achieve competitiveness, and likely to result from further research investments.

Current Status Of Biobased Product And Bioenergy Production

The Strategic Plan of the Federal government's Biomass Research and Development Board (R&D Board) has catalogued the current use of biobased products and bioenergy in the United States.(7) It reports that renewable resources are the source of more than 300 billion pounds of carbon-based products each year – primarily forest products. The report also indicates about 300 billion pounds of carbon-based products are produced by the U. S. chemical industry each year, with most of this being sourced from fossil resources such as coal, oil and natural gas. Some of these carbon-based products are from biobased sources, and the whole product area represents a rich opportunity for biobased products that offer lower cost, superior performance and improved environmental impact.

Two private sector ventures that focus on developing biobased products are of particular note.(8) The first is a collaboration of Cargill, Inc., an integrated agribusiness firm with world-wide business interests in livestock, grain, food input manufacturing and food products, and Dow Chemical Co., an integrated chemical firm with world-wide business interests. The Cargill Dow LLC they formed will soon produce and market a biobased material produced from corn, a polylactic polymer called NatureWorks (trade mark protected) with a range of uses in plastics, clothing and home/office furnishings applications. An initial processing plant has been opened in Blair, Nebraska.

The second venture is by DuPont, another integrated international chemical company with world-wide business interests. The firm has developed a process to create a 3GT polymer that is biobased. It is named Sorona (trade mark protected). This product has particularly desirable use characteristics and wide ranging applications in clothing, upholstery and textiles. DuPont believes Sorona is the first, in what will become a broad family of biobased products produced by the firm. Two DuPont partners in the development of this product are Genencor International and Tate and Lyle.

By 2003, DuPont plans to have a commercial scale plant in operation using corn-sourced dextrose as a feed stock to produce the PDO polymer used to produce Sorona.

Biomass sources for energy provide only about 3 percent of the primary energy in the United States.(9) About 25 million homes use wood for primary or supplemental heating, with wood providing about 10 percent of total U. S. residential heating. Biomass residues, municipal waste and landfill gas account for nearly 1 percent of the electric power generating capacity in the United States. Biomass residues, municipal wastes and landfill gas generate heat and 60 billion KWh of electricity annually.

Biomass from process streams and residues provide 56 percent of the heat and electric power used by the pulp and paper industry and 75 percent of the heat and electric power used by the solid and engineered wood products industries. Finally ethanol, principally produced from corn, accounts for about 1 percent of liquid fuels in the U. S. Ethanol is used as a blend in about 3 percent of the U. S. gas supply. Biodiesel, produced from vegetable oils or used yellow grease, has had a minimal market share so far. Annual liquid biobased fuel use currently (2000) includes about 1.64 billion gallons of ethanol and about 6 million gallons of biodiesel.

U. S. biopower production currently is greater than the electric power production and consumption from all sources in many individual countries such as Portugal, Greece, Chile or the Philippines. In the past two decades, 730 bioenergy powered electric generating facilities have been constructed in the United States, and many others produce heat only. Fifty-eight ethanol production plants have been built (including two under construction), as well.

Status Of Related Federal Government Activity

Fiscal year 1998 research and development funding for biobased products and bioenergy, across the Federal government, totaled $253.3 million. Table 1 displays the subject areas in which the expenditures occurred and the investment made.

USDA Role in Bioproducts and Bioenergy Development

USDA has encouraged development of U. S. biobased resources in a number of ways.(10) Funding of research is one important component. Support for demonstration projects and commercialization also is important. USDA's primary activities focus on research and development. The Agricultural Research Service is the in-house research arm of USDA with several Federal laboratories across the Nation. In its programs, new and advanced technologies are developed, modified and utilized to convert animal and plant components – protein, oil/fat, starch, fiber, and processing byproducts – to new products, and to develop new crops to meet niche market opportunities. The primary focus is to develop industrial and bioenergy products that can meet environmental needs, replace exports and petroleum-based products and expand market opportunities. ARS partners with private industry in development of products through agreements with individual firms.

TABLE 1: FEDERAL R&D FUNDING FOR FISCAL 1998

AREA	FUNDING IN MILLION US $	PERCENT OF TOTAL
Bioenergy Science	$53.5	21.1%
Biofuels	$47.5	18.8%
Crosscutting Science of Biobased Products	$34.8	13.7%
Green Chemicals and Plastics	$34.7	13.7%
Biomass Resources	$24	9.5%
Biopower	$23.7	9.4%
Natural Structural Materials	$17.6	6.9%
Natural Fibers	$12.3	4.9%
Integrated Assessments	$5.2	2.1%

Source: *Fostering the Bioeconomic Revolution in Biobased Products and Bioenergy,* Biomass Research and Development Board, January, 2001, page 5.

The Cooperative State, Research, Education and Extension Program (CSREES) is USDA's principal link to academia and participates in a nationwide agricultural research planning and coordination system that includes State land-grant universities and the agricultural industry. CSREES promotes research and development for biobased industrial products and bioenergy through these programs: Agricultural Materials, National Research Initiative, and Small Business Innovative Research. The programs focus on basic and applied research and product development.

The Forest Service undertakes a wide range of research in bioproducts and bioenergy development at its North Central Research Station, Southern Research Station, Forest Products Laboratory and other locations. Finally, the Natural Resources Conservation Service provides technical assistance to producers to help them sustain, conserve and enhance their natural resources, including environmentally sound animal waste management. The Office of Energy Policy and New Uses coordinates development of energy policy within the USDA and advises the Secretary on energy policy issues.

Department of Energy Role in Biopower and Biofuels Development

The Department of Energy (DOE) supports a program of research and development of biopower technologies that have the capacity to make important contributions to the U. S. energy supply by 2010.(11) DOE works in collaboration with private sector entities and other Federal agencies in conducting its research program.
The program includes field validation of technologies, tested for producing power in a wide range of

settings and applications. Its research and development program includes projects that cover near term, mid term and long term efforts. An integrated approach is employed that encourages commercialization of near term options and sets the stage for commercialization of more advanced technologies. DOE's program benefits the U. S. economy by helping to revitalize rural economies, creating jobs in biopower production and co-products and improving environmental sustainability by reducing the release of greenhouse gases.

DOE's biofuels program focuses on research, development and demonstration of technologies that support growth in an integrated domestic biomass-based industry with the capacity to reduce reliance on imported fuels. This program has identified ethanol as the most promising near/mid term liquid fuel option for transportation. It supports development of energy crops and the production, harvesting, handling and conversion/processing technologies needed to make ethanol commercially successful. Special attention is focused on developing enzymes that can efficiently and cost effectively break down cellulose into simple sugars. Success in this endeavor will enable the use of agricultural and forest residues in the production of ethanol. In addition, support is provided to an alliance, at state and local levels, focused on overcoming barriers to using biofuels.

Recent Federal Government Actions Supporting Biomass Development

In 2000, Congress enacted Title III of the Agricultural Risk Protection Act (P.L. 106-224), the Biomass Research and Development Act of 2000. The legislation brought new focus to public sector involvement in the conversion of biomass into biobased industrial products, including bioenergy. The legislation's goal is to make biobased industrial products cost-competitive through the discovery and application of new technologies, and by other means to reduce the cost of converting biomass into desired biobased industrial products. The authority provided under the legislation sunsets at the end of 2005. The legislation authorized, but did not appropriate, up to $49 million to USDA for research and development to be coordinated with other departments and agencies, to carry out the Act's provisions for each of the five years in which it is in effect.

This legislation called for increased coordination across Federal government departments and agencies associated with biomass research and development. The USDA and the DOE were designated as the two lead departments in that effort. An R&D Board made up of senior representatives from these two departments and other departments and agencies was created to manage the increased coordination. Other government entities that are members of the R&D Board include: the National Science Foundation, the Environmental protection Agency, the Department of the Interior, the Office of Science and Technology Policy, the Department of Commerce, the Environmental Executive, the Office of Management and Budget, the Department of the Treasury and the Tennessee Valley Authority.

An advisory committee was established under the Act to assist the Secretary of Agriculture and the Secretary of Energy on technical issues related to the requests for research proposals issued under the Act, and evaluation of those proposals.
The Advisory Committee also will facilitate consultations and partnerships among different levels of

government agencies, agricultural producers, industry and consumers.

The R&D Board issued its initial strategic plan in January of 2001. The plan proposed a national goal of tripling the use of emerging biobased products and bioenergy by 2010. That goal is premised upon achievement of several technology development, market and public policy goals. The technology development goals focus on improvements in cost effectiveness of production, conversion and application of biobased systems. The market and public policy goals focus on developing and coordinating policies that encourage adoption and use of biobased products and bioenergy, including Federal use.

Two recent programs to increase biofuels production and to demonstrate biomass for electric power generation indicate Federal government support for product development:

- **The Commodity Credit Corporation (CCC) Bioenergy Program:** USDA's CCC made available to producers of eligible biofuels, up to $150 million in FY2001 and up to another $150 million in FY2002, in incentive payments to those producers who increase their production of eligible biofuels over the previous year. Funding for the year 2001 was fully subscribed with 54 agreements representing 79 plants in 19 states, with 42 ethanol and 12 biodiesel producers signing agreements projecting possible increased production of up to 246.2 million gallons of ethanol and 36.5 million gallons of biodiesel.

- **Pilot Projects To Use CRP Land To Produce Biomass Feedstock:** USDA has solicited proposals for pilot projects that use harvested vegetation to produce energy. Seven proposals have been received and are being evaluated. Four proposals have been approved in Iowa, Minnesota, New York, and Pennsylvania. Two more projects will be selected in the near future. The land from which the vegetation will be harvested must be enrolled in USDA's Conservation Reserve Program and the vegetative cover, such as grass, must be approved cover for use in the conservation program. Pilot projects will be for a minimum period of 10 years and the total acreage per project may not exceed 50,000 acres. The maximum acreage for all pilot projects will not exceed 250,000 acres.

Moving Products From The Research Bench Into The Market Place

In order to achieve the objectives in the R&D Board's strategic plan, a systematic approach is needed to move research findings from a scientist's bench into the commercial market place. That approach is underpinned by a strong research program. Necessary improvements in productivity of feedstock production, efficiency of conversion and processing and market competitiveness of end products are challenges research can resolve.

But to be successful, the approach also requires independent testing of the products against their fossil fuel based alternatives to determine life cycle costs, environmental footprint and product performance in use. Early in the development of these bioproducts, public sector funding may be necessary to support this activity.

It is increasingly apparent that biobased products and bioenergy must be sold to the consuming public on the merits of their life cycle costs, environmental attributes and product performance. Competing with fossil fuel based products only on the basis of price is not likely to be successful.

Product development and commercialization incentives often will be needed to encourage producers to invest in new equipment and processes. Strategies such as tax credits for initial innovators may be necessary. Loan guarantees to encourage private sector debt capital involvement in plant and equipment financing, strategies such as public/private sector partnerships in initial commercialization, strategic alliances and access to risk management tools can all be important in enabling early stage bioproduct and bioenergy commercialization. An example is the current use of limited-time-frame U. S. tax credits for wind energy and closed loop biomass production.

Other components of this systematic approach are the use of public sector demonstration and procurement projects. Regulatory initiatives can also be important in supporting market development for biobased products and bioenergy. In the United States, most environmental regulations typically do not distinguish between fossil based and biobased products when applying a regulatory regime.

Public policy actions that increase initial use of biobased products and bioenergy can be helpful in demonstrating the performance and environmental attributes of these products. Public policy actions can also help new industry initially develop a level of production needed to reduce the per unit cost of the product to consumers. Examples of such actions are support for government procurement of biobased products and bioenergy, a renewable content requirement for liquid fuels or electric power sold to the consumer and a requirement that biobased products and bioenergy be offered to consumers as alternatives to fossil fuel based products.

A final, and critically important component of the system approach is an ongoing education program that provides sound science-based information on these products and their attributes. The R&D Board funded a National Education Workshop this summer. This workshop brought education experts together to identify the necessary components (knowledge base) of a sound education program to support biobased product and bioenergy use. It focused attention on three education initiatives: K-12 education, outreach education to consumers and centers of excellence for colleges and universities, to assure education of workers and development of technology to support a new biobased economy.

New Presidential Policy Proposals

President Bush's National Energy Policy Development Group has just issued its report, *Reliable, Affordable, and Environmentally Sound Energy for America's Future*.(12) That report included the following initiatives that, if implemented, will facilitate development of biomass based energy resources:

- Access to Federal lands will be re-evaluated to increase renewable energy production (including biomass);

- A new renewable energy partnership program will help companies more easily buy renewable energy;
- Legislation will be proposed to extend and expand tax credits for electricity produced using wind and biomass. The present 1.7 cent per kilowatt hour tax credit would be extended, and an expanded eligibility for biomass sources would include open loop biomass generation from forest-related sources, agricultural sources and electricity produced from biomass co-fired with coal; and
- The Secretary of the Treasury will work with Congress to continue the ethanol excise tax exemption, currently scheduled to expire in 2007.

What Are The Business Opportunities?

The National Research Council Report, *Biobased Industrial Products: Priorities for Research and Commercialization* set out targets for a national biobased industry (Table 2). These represent what the best U. S. scientists working in this area believe are achievable.

TABLE 2: Production Targets For A National Biobased Industry

Biobased Production Levels (% Derived From Biobased Feedstocks)

Biobased Products	Current Level	Intermediate Target (2020)	Future Target (2090)
Liquid Fuels	1 to 2 %	10 %	Up To 50%
Organic Chemicals	10%	25%	90+%
Materials	90%	95%	99%

Source: *Biobased Industrial Products: Priorities for Research and Commercialization*, National Research Council, National Academy Press, Washington, DC, 2000, page 105.

Against this dramatic vision, the U. S. government, with bi-partisan support from the U. S. Congress, is initiating a coordinated effort focused on research and development of biobased products and bioenergy to deliver on that potential. The results of this effort can create opportunities to develop new industries and to fundamentally change those sectors of the economy that provide inputs and services to these new industries.

Key Areas of Promise

Because of advances in organic chemistry, cellular biology, genetics and plant breeding, with important dependence on biotechnology, it is now (or soon will be) possible to use plants to create compounds, or precursors to those compounds, that previously was done in fossil fuel refining or in laboratories.

The R&D Board identified two important building blocks obtained from biomass that can, in turn, become the source of a wide range of products. These are sugars and biosynthesis gas.(13) Sugars are called the key starting point from which a wide range of biobased products can be created. From sugars, alcohols can be derived for use as a liquid fuel (ethanol), glycols for solvents, and sorbitols for adhesives and other uses. Acids can be produced for use as a starting material for biodegradable plastics. Polymers can be used as a gel in medicine and paints.

Biosynthesis gas, primarily a mixture of carbon monoxide and hydrogen, can be used to produce a number of products, once cleaned of its impurities. Biosynthesis gas can be used to fire advanced turbines or fuel cells to produce electricity. Alcohols can be produced from this gas for direct use in a number of applications, or as feedstocks for a wide range of industrial chemicals, or as a high performance liquid fuel. Acids can be derived, as well, and used in making a range of textiles, plastics and polyesters. Clean hydrocarbon fuels, containing no sulfur, can also be produced from biosynthesis gas.

Two classes of biobased products merit special mention: bioplastics and surfactants. The chemical industry today produces over 80 billion pounds of plastic products. Biobased plastics could become important competitors in a number of specialty areas, such as textiles, carpeting and biodegradable material. The R&D Board's strategic plan suggests as much as 3 billion pounds of biobased plastics could be marketed annually by 2010.

Surfactants are used in detergents, cleaning products, and medications. Even today, about 35 percent of surfactants are produced from biobased sources; that proportion could grow substantially by 2010. A wide range of biomass feedstocks - wood, starches, lignin polymers, cellulose and biomass natural fibers - also offer substantial opportunity for new product development.

The R&D Board's strategic plan notes that the plant residue-based power business has, over the past 20 years, created about 7,000 megawatts of electric power production capacity. That, in turn, has created about 66,000 jobs. Further research to improve feedstock production and conversion efficiency could result in the biopower industry growing by a factor of three in the next 10 years. If that occurs, the industry could be responsible for creating another nearly 200,000 jobs.

The National Energy Policy Development Group's Report, *National Energy Policy*, provides additional support for the R&D Board's vision.(14) That report identifies areas of the U. S. in which electricity supply conditions are expected to become tight. Those include the Southeast, the Midwest, the Northeast and California. In each of those areas, there is substantial potential capacity to produce biomass for electric power generation. There also is a need for substantial new electric power generation. Production of biomass to provide fuel for new power plants could add substantially to farmer and forester income in those regions. Jobs created in rural areas by both production and processing of biomass feedstocks, and jobs generated by new electric power plants, would add measurably to the economic vigor of rural communities.

The report pointed out that 60 to 90 new power plants will be needed in each of the next 20 years to

meet increased demand for the electric power necessary to sustain projected U. S. economic growth.

The possible removal of methyl tertiary butyl ether (MTBE) as an oxygenate from the U. S. gasoline supply holds substantial promise to increase market demand for ethanol. MTBE has proven to be a contaminant in underground water supplies. Phasing out MTBE over a five year period and replacing it with ethanol could boost demand to over 4.5 billion gallons a year, from the current (2000) consumption level of about 1.64 billion gallons.(15) The phase-out also is likely to stimulate creation of many new cooperatively organized ethanol production companies.
More than 150 farmer (individual farm facilities) and cooperatively owned ethanol processing facilities have started up in last 10 years, almost all in rural locations. However, most farm-based facilities are no longer in operation.

Developing The Tools and Infrastructure

Broad based development of a biobased economy represents a paradigm shift, every bit as fundamental as the shift in dependence from whale oil to petroleum. The capacity of the economy to make that shift and the pace of the shift will be controlled by the availability of specialized physical and, most importantly, intellectual resources. Forward thinking faculty and administrators at colleges and universities will create those intellectual resources in the form of graduates and faculty with the new skills and knowledge necessary for success in the biobased economy.

Major opportunities exist for agribusiness as the shift to a biobased economy, already under way, gains momentum:

- First, there are huge opportunities in plant breeding and seed supply. The biobased economy will be very dependent on creating and marketing plants with specialized attributes and high production efficiency.
- Second, chemical engineers, biochemists, bacteriologists and biotechnologists will develop compounds, enzymes and microorganisms critical to conversion and processing of the end products.
- Third, processing technologies and systems must be developed and maintained. and
- Fourth, equipment companies must develop, manufacture and market new equipment for the collection, separation, and transportation of plant materials, seeds and plant residues to processing, manufacturing and electric power generation facilities.

Opportunities to provide technical and management consultation for production, processing and marketing of products will create almost unlimited business opportunities. Financing requirements for this new industry, both for debt and equity capital, will be very large. New risk management tools for use in the industry also must be created and marketed. Marketing these new environmentally superior products to consumers will open a broad range of opportunities for businesses of all sizes.
Opportunities exist to export technology, equipment and products. Potential demand for these is high in Western Europe and East Asia.

As the U. S. dependence on biobased products and bioenergy grows, more of the initial

processing and production will occur in rural communities. That, in turn holds the opportunity for a market driven renaissance in economic vitality for many of these communities. Rural communities, that often have seen their economic vitality sapped by forces beyond their control, are positioned once again to benefit from the shift to a biobased economy. Not only will the plant-based feedstocks be produced by farmers and foresters in rural areas, but much of the initial processing and manufacturing of products will also take place in rural communities, close to where the feedstocks are produced. Biobased electric power generation will be located in rural areas for the same reasons. The result will be substantial new investment in plant and equipment, broad based job formation and new income generation that can revitalize many rural communities.

The Payoff for Farmers and Foresters

Farmers of differing scale and production sophistication will all benefit from the biobased economy. There will be a range of sophistication required to produce feedstocks. The value of the feedstocks produced will vary, as well. At the lower end of both scales may be the production of biomass feedstock for co-firing electric power generation. At the high end may be growing plants to produce pharmaceutical products. Moreover, many farmers will invest in processing businesses through farmer cooperatives, enabling them to also capture downstream profit margins.

Two analyses help to illustrate the probable benefits for farmers. The first, an unpublished 1999 analysis by USDA's Office of Energy Policy and New Uses, evaluated the effect on farmers of phasing out MTBE use as an oxygenate in gasoline, replacing it with ethanol.(16) The analysis concluded that ethanol production from all crops, at a 1.413 billion gallon level in 1997, would grow to a production level of 3.356 billion gallons (denatured) in 2010. Corn prices were projected to rise by an annual average of 13.3 cents per bushel over the 2000 to 2010 period. Projected net farm income rose by an annual average of $1.084 billion during the period.

The second, a national analysis of bioenergy crop production, was reported by De La Torre Ugarte and colleagues.(17) The authors concluded that up to 42 million acres of crop land could be shifted to switch grass production at a price of $40 per dry ton. That would make bioenergy crops the fourth largest crop produced in the United States, in terms of acres. With that level of switch grass production, net farm income was projected to increase by up to $6 billion. The 188 million dry tons of projected biomass output could have been used to generate nearly 7.3 percent of the 1999 U. S. electricity output.

Conclusion

Greater emphasis on research, development and commercialization of biobased products and bioenergy in the United States is likely. The drivers of energy prices and energy security issues, the need to create new demand for farm products and economic stimulus for rural communities, coupled with the prospective scientific knowledge base and increased environmental sensitivity, all suggest greater emphasis on a biobased economy is likely.

Reducing costs of biobased products and bioenergy combined with increased emphasis on testing and evaluation, as compared to their fossil fuel based alternatives, are all essential keys to moving them into the commercial market place. Public and private partnerships to spur product development and commercialization, along with increased coordination in research and development, will introduce new products and open new markets for biobased products and bioenergy more quickly than previously expected. Finally, private sector initiatives, to meet consumer demand for new products that are more environmentally sustainable, will bring new products to market as soon as economically feasible.

Exciting new opportunities for farmers, agribusiness firms, manufacturers and consumers are just around the corner, providing those involved are prepared to invest resources to bring the opportunities to reality. How quickly this occurs is really a question of whether the national will is harnessed to achieve that goal. The renewed interest is apparent. The necessary steps to achieve the goal are known. There is even a pretty clear understanding of how much public funding would be required - and how much private sector investment could be leveraged as a result. Major progress can be achieved within a ten to twenty year horizon, if the needed investments are made and supportive public policies are put in place.

On balance, introducing a major new source of domestic demand for agricultural and forestry crops can help create a more profitable agricultural production sector and new business opportunities in rural communities.

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