# BIOMASS RESEARCH AND DEVELOPMENT TECHNICAL ADVISORY COMMITTEE RECOMMENDATIONS

**Submitted to**

**Secretary of Agriculture**
**Ann M. Veneman**

**and**

**Secretary of Energy**
**Spencer Abraham**

**In Accordance with**
**Biomass R&D Act of 2000 (P.L. 106-224)**

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## PREAMBLE

This report is submitted by the Biomass Research and Development Technical Advisory Committee to the U. S. Department of Energy and the U. S. Department of Agriculture in response to the charge given to the committee by Congress to develop recommendations designed to advance the availability and widespread use of biobased industrial products and promote rural economies. Given that the context of the congressional charge was both complex and dynamic, spanning interests of two federal agencies, each serving multiple constituencies, the committee devoted substantial effort to examination and explication of the charge in an effort to structure its work appropriately. Predictably, interpretations of the Congressional charge proved to be as diverse as the membership of the committee itself. This prompted discussion focused on the level of detail which the report might deliver, the advisability of the inclusion of specific policy recommendations, and the dilemma of how best to determine optimal authorization and appropriation levels. Ultimately, the committee resolved to address those concerns in this preamble to its submission.

Unanimously, the committee urged that its recommendations not be interpreted as anticipating increased biomass-based utilizations on any other than accepted best practices of environmental management and protection. Further, the committee acknowledged that the advances of science and technology in bio-based resources have progressed at a pace more accelerated than have those of public policy, regulation, or promotion, resulting in a degree of asymmetry in the identification and allocation of bio-based resources. Finally, in respect to the definition of terms used in the report, the committee adhered to the definitions prescribed in existent law. Subcommittee work on both biobased power and biobased fuel strictly adhered to those definitions, while the subcommittee addressing biobased products provided a slightly amended definition in their report. These accords are reflected in the following report, which is divided into four sections following a brief Introduction: Biobased Fuel; Biobased Power; Biobased Products; and Cross-Cutting Themes.

In other respects the report is not as uniform. In that commensurate data was not available for the three subcategories by which the committee divided its work – fuels, power, and products – a consistent scale of analysis was not possible. For example, while absolute volumes of bio-based inputs to power production are precisely known, the volume of bio-based products in the pre-commercialization phase in the private sector cannot be accurately ascertained, necessitating surrogate measures. Moreover, disparities in the temporal scale distinguish each of the three areas of inquiry. While each subcommittee attempted to gauge its recommendations toward the goal of tripling bio-based production by 2020, this goal will likely be accomplished much sooner than that in some applications than in others. Based on current estimates, for example, it is likely that this goal will be met as soon as 2004 for bio-based fuels, because financial incentives and a market for oxygenates in substitution to methyl-t-butyl ether (MTBE) are in place. For biobased power or biobased products, growth will depend on policies such as renewable portfolio standards or the successful application of governmental preferential purchasing programs for biobased products, fuels and power.

Finally, the committee acknowledges that the following report ought not be interpreted as the final word on the potential of bio-based research and development. Rather it is a preliminary overview of the committee's perspectives on how best to mobilize fiscal and non-fiscal resources to triple the impact of bio-based technologies in the promotion of rural economies and improved sustainability of the nation's energy resources.  Over the span of the next two years the committee envisions activities directed toward producing recommendations more finite in scale for allocation of fiscal and non-fiscal federal resources.

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# I. INTRODUCTION

The Biomass Research and Development Initiative (BioInitiative) was established under the Biomass Research and Development Act (Title III of P.L.106-224) in June 2000. The Act recognizes the "outstanding potential for benefit" offered by biomass technologies. The Act also acknowledges the need to integrate and coordinate the diverse R&D efforts currently taking place across the federal government, in industry, and at the state-level. Recognizing the rural economic, national security, and environmental benefits of domestic and affordable bioenergy resources, the Act establishes the framework for coordinating and implementing Federal biomass research.

The primary objective of the BioInitiative is to coordinate the development of environmentally sound and cost-effective bioenergy and biobased products and technologies in order to increase the availability and use of those products and technologies. This includes the development and demonstration of low-cost, value-added feedstock conversion processes that serve as precursors to producing power, steam, fuels, chemicals, and consumer products. Reaching this objective entails developing the process chemistry, biochemistry, separation and recovery technologies, and power generation knowledge needed to process biomass streams to final products.

To aid in the review of existing R&D programs and to assist in offering advice on strategic direction, the interagency Biomass R&D Board was established. The Biomass R&D Board is comprised of a senior official from the Department of Energy, the Department of Agriculture, the Environmental Protection Agency, the National Science Foundation, the Department of Commerce, the Department of the Interior, the Office of the Federal Environmental Executive, the Office of Management and Budget, the Office of Science and Technology Policy, and the Tennessee Valley Authority. The Board is guided by a Biomass R&D Technical Advisory Committee (Advisory Committee). The Advisory Committee provides recommendations on the suggested future direction of federally funded biomass R&D. The members of the Advisory Committee are experts in the field of bioenergy and biobased products. They bring extensive history, technical expertise, and direct experience in the development and application of biomass resources and conversion technologies. Within the Advisory Committee, three subcommittees have been formed to focus on biobased products, biofuels, and biopower. The Advisory Committee members and their respective subcommittees are listed in Attachment A.

Through a series of meetings, Advisory Committee members drafted R&D recommendations for BioInitiative activities during fiscal year 2002. The purpose of this document is to outline those recommendations, which fall into three areas: Biofuels, Biobased Products, and Biopower. It briefly discusses goals and challenges for each of the three topical areas and provides committee recommendations for R&D and non-R&D activities necessary to advance them. Crosscutting recommendations are also outlined.

## II. BIOFUELS RECOMMENDATIONS

### A. Definition

Biofuels[1] are liquid fuels, produced from biomass, that are used in stationary and mobile applications. The Biomass Research and Development Act of 2000 defines biomass as:

> *"any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials."*

### B. Goals

The Advisory Committee has identified three primary goals for biofuels. They are to:

- By 2010 triple production of fuel from biomass sources, from 2000 levels, by removing technology and policy barriers.
- Provide benefits to farmers and forest landowners by increasing the value of agricultural and forestry products and assisting rural communities with economic development.
- Encourage investment by mitigating the financial risk involved in biofuels.

### C. Challenges

Although important growth in biofuels consumption has occurred since 1999 there remain several technical and institutional challenges obstructing further increases in the use of biofuels. On the technical end, the growth of the biofuels industry will depend on its ability to effectively use all available environmentally appropriate feedstocks including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials. For the industry to make use of these resources, technologies that efficiently and inexpensively convert biomass feedstocks must be developed. The industry also needs improved chemical conversion technologies for the production of biodiesel along with enzymes and fermentation methods that can handle a greater variety of feedstocks and process them more efficiently into fuels. These technologies will help to bring down the cost of biofuels.

Institutionally, the environmental benefits of biomass-based development must be properly codified and any related environmental issues must be appropriately addressed. These activities must be complemented by methods for developing and integrating effective management practices for crop production, transportation, and analysis. The management practices should be adapted from existing uses. Additional challenges include overcoming ethanol and biodiesel utilization issues and the need to develop a sufficient distribution infrastructure to transport biofuels from production locales to a broader market area on a large scale. Furthermore, these institutional and R&D solutions need to be integrated by biorefinery facilities that use the full

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[1] Section 303(2) of the Biomass Research and Development Act of 2000 defines biobased industrial products as "fuels, chemicals, building materials, or electric power or heat produced from biomass."

value of all available environmentally appropriate feedstocks. The biorefinery concept must be fully demonstrated and a method to transfer results to industry must be developed. In both the technical and institutional areas, particular attention must be paid to the fuel user community including increased attention to the properties and economics of combustion and gasification systems.

## D. R&D Recommendations

The Advisory Committee has identified a number of areas in which research is needed to increase the use of biofuels, including:

**Lignocellulosic Materials Research** - The most valuable way to improve the availability of biofuels is to develop advanced methods of overcoming the resistance of agricultural, forest-based, and urban feedstocks to enzymatic and fermentation treatments. Current technologies for creating a treatable/fermentable product from available, environmentally appropriate biomass sources do not meet the needs of the industry. Additional research into the fundamental structure of lignocellulosic materials, including the chemistry of its cell wall structures, transport properties, and genetic properties, is required in order to improve growth rates and processing characteristics and make sufficient inexpensive resources available. At the same time, research into the agronomic, economic and environmental impacts of harvesting lignocellulosic material must be established to ensure that the use of these materials results in beneficial lifecycle impacts.

**Pretreatment** - In order to make utilization of both current and new feedstocks more effective, less expensive pretreatment processes are required. Advanced pretreatment will improve the cost and effectiveness of biomass conversion processes.

**Catalytic and Chemical Processing –** Catalytic and chemical processes for converting vegetable oils and animal fats into biodiesel are currently in use. R&D is necessary to improve the efficiency of processes and make them more cost competitive with non-biobased products. As part of the development of the broader biorefinery concept, traditional thermo-chemical and catalytic processing will be important for conversion of starches, sugars and cellulosic materials into fuel.

**Sensors** - A quick, cost-effective system for on-line real-time analysis and maintenance of feedstocks must be developed. This system should monitor and maintain feedstock quality through the collection, storage, and transportation phases of the product life cycle. Additionally, systems should monitor growth so that harvest can occur at the optimum time for conversion.

**Biorefinery –** Biorefineries could potentially use complex processing strategies to efficiently produce a diverse and flexible mix of conventional products, fuels, electricity, heat, chemicals, and material products from all available, environmentally appropriate biomass feedstocks. The biorefinery concept must be evaluated and developed into real world models. Simple biorefineries are present today in some agricultural and forest products facilities. These systems can be improved through better utilization of waste products and by applying the lessons learned from existing facilities to comparable situations. These facilities convert wastes to fuel material and also upgrade fuel materials to product raw materials. The forest products and agricultural industries also produce by-products and residue products that are commonly under-utilized or treated as waste. Finding higher-value uses of these products, as fuel should be a primary goal along with improving the processing efficiency of existing facilities.

**Utilization** - Research must also examine the fundamental properties of biofuels in pure form and in combination with petroleum-based fuels. For example, in the case of ethanol, fundamental research could help overcome questions of vapor pressure, ozone impacts, ethanol life-cycle impacts, and transportation.

**Systems Management** - The systems that compose the biofuels industry include feedstock production and harvesting, feedstock transportation, fuel production, transportation of finished products, and distribution to end-users. These systems need best management practices and models to improve systems management and ensure overall systems integration and coordination.

## E. Non-R&D Recommendations

The Advisory Committee has identified several non-R&D areas in which government activities can help to increase the use of biofuels.

**Consistent Long-Term Policies** - These are necessary to ensure the availability of loans and investment funding and to provide a sound footing for the development of new technologies. Current incentives such as the ethanol tax incentive have catalyzed the development of the fuels industry. In order to maintain the growth of the industry, financial incentives such as tax incentives should continue and incentives for other fuels including biodiesel should be investigated.

**Coordinated Federal Effort -** Increased integration is needed between the U.S. Department of Energy and the U.S. Department of Agriculture in performing bioenergy and biobased products research, working with industry to identify research priorities, and transferring the results of research to industry. In addition, both the Environmental Protection Agency and the U.S. Department of the Interior should be involved in ensuring the greatest positive results for the environment and the use of public lands.

**Standards and Incentives** - The market for fuels is driven by a variety of forces. The federal government has the power to encourage the use of biofuels through fleet standards, fuel standards, oxidation standards, and incentives. The government should work to continue the development of these mechanisms with the goal of creating positive environmental and efficiency impacts while driving the fuels market.

## III. BIOPOWER RECOMMENDATIONS

### A. Definition

Biopower[2] includes new installations using 100 percent biomass or a blend of biomass and fossil fuel; the installation of co-firing systems at existing fossil fuel-based generating stations; and repowering options involving biomass. The Biomass Research and Development Act of 2000 defines biomass as:

> *"any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials."*

### B. Goals

The Advisory Committee has identified three primary goals in the area of Biopower. They are:

- Triple the amount of biomass used in the production of electricity, heat, steam or combined heat and power by 2010.
- Provide benefits to farmers, forestland owners, and other generators of biomass feedstocks and aid rural development by maximizing the number of opportunities for the production of electricity and combined heat and power through the use of new or advanced technology.
- Increase the efficiency of biomass conversion to power with new technologies and best management practices.

### C. Challenges

There are a number of challenges that must be overcome in order to reach the goals identified above. One challenge is to reduce costs for capital equipment and facility startup. This involves learning how to effectively and efficiently size and site both new and add-on facilities; how to enable local production using all available, environmentally appropriate feedstocks; and how to obtain access to and establish use of the transmission grid. Also, regulatory certainty is a major challenge for siting and permitting of facilities. A more efficient process is needed for environmental permitting of both new installations and retrofits of existing installations. Overcoming this challenge will also require the establishment of efficient regulatory certainty by developing comprehensive consensus-based criteria for the performance and environmental impacts of biopower technologies.

Another challenge involves improving solid and gaseous feedstocks by reducing their delivered cost while increasing availability and quality. Current systems are inadequate to convert large quantities of biomass feedstocks, especially low energy intensity waste biomass solids and gases,

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[2] Section 303(2) of the Biomass Research and Development Act of 2000 defines biobased industrial products as "fuels, chemicals, building materials, or electric power or heat produced from biomass."

to useful sources of power. The technologies to overcome these challenges must be developed through targeted R&D.

These two challenges must be addressed in conjunction with the policy issues that face the industry. Policy questions relate to existing and proposed subsidies for biomass-based generation, incentive systems that encourage methane recovery, permitting and compliance with siting and environmental regulations, and awareness and education of power developers and generators.

## D. R&D Recommendations

The Advisory Committee has identified the following areas in which biopower research and development, demonstration, and technology transfer are necessary.

**Thermochemical Conversion –** Necessary research into thermochemical conversion of biomass feedstocks including direct use of gaseous products includes: basic and applied research and feasibility studies, research on the integration of conversion systems with power generation equipment, and overcoming technical barriers such as tar removal prior to firing biogas in a turbine system. In addition, analytical studies on costs, performance, and life-cycle emissions are necessary.

**Co-firing** - Co-firing of biomass with coal, oil, or gas has the greatest potential for increasing biomass power generation by 2010. To increase the application of both existing and emerging technologies, there is a need for increased technology demonstration and technology transfer activities. Initial priorities include cyclone boilers and co-fired fluidized bed boilers. Co-fired pulverized coal boilers and related feed systems are nearly ready for commercial demonstration. One area with unrealized potential is gasification-based co-firing, which will integrate this advanced boiler technology with oil and natural gas-fired boilers and combined cycle combustion turbines (CCCT's) through the use of duct burner technology or other appropriate co-firing technology. Continued R&D is needed in each of these systems to broaden the range of usable feedstocks to include all available, environmentally appropriate feedstocks. There is also a need to develop design standards and permitting standards in electronic form, as well as to enhance technology transfer to feedstock producers and electric power developers.

**Direct Combustion** - Another method for increasing biomass power generation is direct combustion of 100 percent biomass in units of 75 megawatts or less. A commercial demonstration program for this technology is required along with development of units that operate at higher main steam temperature and pressure (>1500 psi) for increased efficiency. Development of a reheat boiler based on biomass firing merits additional research. Particular attention should be paid to technology transfer for existing use of multiple fuel boilers in the forest products industry. Other factors that will improve this process include improved burner design, a better understanding of the combustion characteristics of feedstocks, and design and permitting standards in electronic form.

**Thermal Gasification** - Thermal gasification has great potential for increasing biomass power generation beyond 2010. Waste sources from the forest products industry represent 30 GW of potential output. The forest products industry and relevant federal biomass research programs should remain informed of advances in DOE Fossil Energy research in gasification technology and hot and cold gas clean up, and coordinate with the Fossil Energy program as appropriate. Key developments should include small modular biopower systems that use small gasifiers. As noted previously, gasification can also be applied to co-firing with particular application to CCCT installations.

**Anaerobic Fermentation Gases** - Power from anaerobically generated gases has great potential for increasing biomass power generation beyond 2010. The sources for these gases include 500 Btu/cu ft gases from landfills, anaerobic digestion of animal manure and food/feed/grain products and by-products, use of wastewater treatment digestion gas, sludge and sewage treatment gases, and other sources. Over 600 million tons of carbon equivalent methane is produced annually in the U.S.[3] Low intensity methane should be viewed as a resource instead of a waste product. Systems for the use of methane from 10 – 300 Btu/cu ft are technically feasible and should be developed. Research on integrating thermal gasification with anaerobic digestion provides another opportunity for synergies between technologies.

**Modular Systems** - Advances also need to occur in the development of modular systems and distributed small-scale generation of less than 200 kW. Systems should be developed that can consume small caches of waste or dedicated resources for distributed generation of power and heat locally for use on-farm, on-site, and in small industrial systems. The alternatives developed could include integration of modular biomass systems with fuel cells. Resources include food/feed/grain processing plant waste: nutshells, corncobs, tomatoes, carrots, fruit, rice hulls, as well as urban and wood waste, and other sources. There is potential for limited development before 2010 and widespread use after 2010. The primary R&D opportunities in this area are the development of scaled-down, skid-mounted or mobile installations and fuel concentrators to increase energy density. Significant opportunities for modular systems exist in low value by-products from grain, soy, wood and other processing systems, and in farm and forest residues where the high cost of transporting biomass to larger facilities can be avoided.

**Feedstock Research** - The above systems must be complemented by research into feedstock issues including improvements in: energy and tree crop growth (GMO/ rate/ quality/ hardiness) and management, feedstock collection, transportation, crop and tree cycle integration, residue recovery and fuel preparation. R&D opportunities include overcoming the seasonal nature of generation, improving storage methods, developing open and closed systems, expanding the growth of energy crops, and assuring the quality of feedstocks. At the same time, research into the agronomic, economic and environmental impacts of harvesting lignocellulosic material must be established to ensure that these materials are used for beneficial lifecycle impacts.

[3] U.S. Environmental Protection Agency, Global Warming Site: National Emissions, http://www.epa.gov/globalwarming/emissions/national/methane.html.

## E. Non-R&D Recommendations

**Increased Integration** - USDA and DOE should increase the level of coordination in biopower-related research, technology transfer, and commercialization activities.

**Consistent Long-Term Policies** - These are necessary both to ensure the availability of loans and investment funding and to provide a sound footing for the development of new technologies. As part of this, DOE, USDA, EPA and DOI should work together with industry, environmental, and other groups to develop comprehensive consensus-based criteria for performance and environmental impacts of biopower technologies.

**Systems Management** - The systems that compose the biopower industry include feedstock production and harvesting, feedstock transportation, and conversion technologies. These systems need best management practices and models to improve systems management and ensure overall systems integration and coordination.

**Standards and Incentives** - The market for electricity is driven by a variety of forces. The federal government has the power to encourage the use of biopower through the use of financial incentives, abatement and waste utilization credits, public benefits funds, renewable portfolio standards, and federal procurement policies. The government should work to continue the development of these mechanisms with the goal of creating positive environmental and efficiency impacts while driving the biopower market.

**Removal of Barriers to Distributed Generation** - DOE and USDA should work together to ensure that investment in environmentally sound biomass technologies is not impeded through the use of unduly burdensome interconnection standards, inflated insurance requirements or other artificial market barriers.

## IV. BIOBASED PRODUCTS RECOMMENDATIONS

### A. Definition

Biobased products[4] are products made from biomass. The Biomass Research and Development Act of 2000 defines biomass as:

> *"any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood wastes and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials."*

The Advisory Committee adds to the definition by excluding the following categories of products that are conventionally made from biomass:

- Paper, lumber, and other conventional wood products
- Food, food ingredients, and food by-products
- Pharmaceuticals and "nutraceuticals"
- Textiles from Natural Fibers

### B. Goals

The Advisory Committee goals in the area of Biobased products are divided into two timeframes.

By 2010, industry will expand the use of biobased products that have been commercialized or are already under development. Specific goals are:

- Triple the consumption of biobased products from the current baseline, estimated to be 10-15 billion pounds produced per year[5].
- Improve the health of rural economies through greater development and application of biobased products.
- Reduce the environmental impacts associated with the production and use of numerous industrial and consumer products through increased use of environmentally friendly biobased products.

By 2020, industry will:

- Expand the use of biobased products to replace 10% of the petroleum-based product market. This will be accomplished through both basic and applied research.

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[4] Section 303(2) of the Biomass Research and Development Act of 2000 defines biobased industrial products as "fuels, chemicals, building materials, or electric power or heat produced from biomass."

[5] Biomass Research and Development Board, "Fostering the Bioeconomic Revolution"; January 2001.

## C. Challenges

Currently, hundreds of biobased products are available and commercially competitive. The U.S. Department of Commerce estimates that almost 550 million pounds of soybean oil are used annually in industrially used products such as paints, solvents, and plastics[6]. Research through the 1990s has led to many new biobased products. These include polylactic acid and propanediol, soy polyurethane products, soy protein adhesives, water-borne soy coatings, soy and corn solvents, vegetable oil lubricants, soy and corn thermoset plastics, and a host of organic acids derived from established crops. However, many of these new products are in the development, pre-commercialization, or early commercialization stage. There is a lack of business awareness about the cost, environmental, and performance advantages that these products represent. Much of the existing technology has not been proven under "real world" conditions and/or faces significant certification challenges. These certification challenges are often the result of systems that set standards based on the physical characteristics of petroleum products, rather than on the performance of the end product. As a result, the perceived risks outweigh the value of the potential market. The lack of business awareness is compounded by the lack of consumer awareness. Currently, low market demand for biobased products deters many current and would-be producers from incurring the financial risk of developing or expanding production of biobased products.

Another challenge facing biobased products is the lack of economical fractionation technologies and separation processes. The same basic chemicals found in fossil hydrocarbons are also found in renewable carbohydrates. Effective, economical combinations of traditional thermo-chemical and biological processes as well as the ability to recover high yields of relatively pure chemical streams are needed. If these technologies could be developed, they would greatly expand the range of raw materials that could be used for developing biobased products.

Increased application of biobased products will require the development of a production, collection, processing, and distribution infrastructure that is adequate to supply biobased product markets. Established crops such as corn, soy, wheat, rice, and even livestock have production, harvesting and collection systems already in place, making it reasonable to initially expend more effort in these areas.

Finally, there is the need to develop a larger pool of qualified experts in the biobased product research community as well as a new qualified and well-trained workforce. In addition, marketing and manufacturing plans need to become a standard part of the analysis of proposed research projects.

## D. R&D Recommendations

The Advisory Committee has identified several technology R&D priorities.

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[6] U.S. Department of Commerce, "Fats and Oils: Production, Consumption, and Stocks". Available at [www.census.gov/cir/www/m20k.html].

**Genetically Enhanced Crops** - Research is needed at the genetic level to produce crops with desirable traits for both edible and industrial uses. Simply increasing the plant's natural production of a specific component already found in the crop, such as a protein or fatty acid, can increase the ultimate yield of that component and thereby improve efficiency and reduce the cost of biobased product production. Longer-term genetic research could change the chemical composition of plants to produce crops with new chemical compositions that are much closer to the final industrial product. At the same time, the impacts of genetically enhanced crops must be assessed on a species-specific and ecosystem level to ensure that there are no negative impacts associated with the genetic alteration.

**Fractionation & Separation –** Traditional agriculture and forest crops urban waste, and crop residues represent a major source of readily available complex proteins, oils and fatty acids, as well as simple and complex sugars to be used as raw materials. These materials are available at low cost in localities across the U.S. There is a need for R&D to develop low-cost chemical and biological processes including new chemistry and thermochemical synthesis that can break down these molecules and separate the resulting components into purified chemical streams. New concepts need to be developed, and past separation technologies should be reexamined, to reduce costs in downstream processes. Research could focus on engineering and biological principles as well as combinations of both to improve product purification.

**Biomass Fermentation and Hydrolysis** - Research is needed to enhance the process of fermentation and hydrolysis of fiber, oil, starch, and protein fractions of crop components and processing by-products. In addition to the need to enable more rapid cellulose conversion to fermentable substrate, there is a need to develop new fermentation technologies to enable production of base chemicals, pharmaceuticals, and chemical intermediates from the wide range of existing crop components. This should include genetic research to develop new microorganisms with the ability to provide useful high-value products from a wide variety of feedstocks.

**Processing Research –** Necessary processing research includes new chemistry for catalysis and biocatalysis to cost-effectively modify biomass to products. Also necessary is improved catalytic synthesis of gases to chemicals and improved pyrolysis to produce chemicals. Furthermore, processing systems must optimize mass transfer of oxygen and nutrients for bioorganisms and optimize the fermentor environment. At the same time new methods to use the results of the processing technologies will also be useful.

**Pilot Plant Demonstration Projects –** Industry, universities, and the national laboratories should work together on pilot plant facilities that focus on evaluating and developing processing technology for biobased products using a variety of raw material resources. Existing pilot plant facilities should be inventoried and utilized in a cooperative fashion with university and industry research efforts to prove and optimize production techniques and economics. Intellectual property rights will have to be negotiated with industry and universities to provide them with the incentive to participate. Special consideration should be given to farmer owned cooperatives in licensing technologies developed with government support.

**High-Value Proteins** - Current efforts to develop new polymers and resins from vegetable and animal proteins need to be expanded to accelerate the development of additional biobased products.

## E. Non-R&D Recommendations

The Advisory Committee identified several non-research recommendations where there is a role for greater federal involvement. These include:

**Integrated Federal and Industry Coordination** - Increased coordination is needed between DOE, USDA, and all other federal agencies on bioproducts-related research. In addition, DOE and USDA should work closely with industry to develop Roadmaps and Visions to assist in identifying collaborative, long-term R&D priorities and goals. Consideration should be given to the need to collect and publish a comprehensive database of past and current biobased product research including the development of a clearinghouse for information on such research.

**Market Pull Strategies** - To achieve the 2010 goal, greater focus is needed on increasing the market demand for these products. There is a need for a cohesive and consistent long-term policy to develop and promote biobased products. Options could include:

- financial incentives for biobased products
- implementation of procurement policies that promote biobased products
- incentives to reduce the risk of developing the supply and distribution infrastructure needed for biobased products to reach their full potential
- partial financial support of highly promising biobased technology at the proof-of-concept stage
- expansion of investment programs designed to stimulate small businesses in the area of biobased product development
- collaborative R&D funding to remove the remaining technological and process barriers to those products that are near the commercialization stage
- federal environmental mandates that encourage the use of biobased products

**Standards Development –** An effort should be made to demonstrate that biobased products are both as effective and affordable as their non-biobased competitors. This can be facilitated by developing and publishing standards for life cycle and economic assessments and conducting demonstration projects.

**Education and Outreach** - Government and industry should work together on education and outreach campaigns to educate potential customers on the benefits of biobased products and to increase consumer awareness.

**Enhancing the Supply of Biomass -** The land set aside by the Conservation Reserve Program and other stewardship programs, and currently overcrowded forestland could potentially be used to grow biomass for use in biopower, biofuels and biobased products. For example, some CRP lands may be suitable for harvest of perennial grasses, trees, and energy crop production while preserving soil and providing other benefits including wildlife habitat, carbon storage, and clean water.

## V. CROSSCUTTING RECOMMENDATIONS

There are a number of crosscutting R&D opportunities that will benefit biofuels, biopower and biobased products. This R&D is necessary to achieve the full potential offered by technologies in these areas. Crosscutting research areas include:

**R&D Recommendations**

- **Industrially Useful Crops -** Research is needed at the genetic level to produce crops with desirable traits for both edible and industrial uses. This research should include increasing a plant's natural production of a specific component, changing the chemical composition of plants to produce crops with new chemical compositions, and increasing the physical size, speed of growth, and durability of feedstocks. At the same time, the impacts of genetically enhanced crops must be assessed on a species-specific and ecosystem level to ensure that there are no negative impacts associated with the genetic alteration.

- **Product Recovery and Storage–** There are numerous opportunities to improve methods of feedstock recovery, storage, and transportation. Research should include recovery, handling and storage technology and procedures. There are significant opportunities to improve residue recovery and utilization from forestry and agriculture, including improving crop growth rates, crop quality and hardiness, crop recovery technology, and separation technology. There is a need to better understand the results of residue removal and to develop improved processes for collecting materials as part of the silvicultural and agricultural harvesting processes.

- **Biomass Fragmentation –** Traditional agriculture and forest crops, urban waste, and crop residues represent a major source of readily available complex proteins, oils and fatty acids, and simple and complex sugars to be used as raw materials. These materials are available at low cost in localities across the U.S. There is a need for R&D to develop low-cost chemical and biological processes including new chemistry and thermochemical synthesis that can treat, and break down these molecules and separate the resulting components into purified feedstock streams. New concepts need to be developed, and past separation technologies should be reexamined, to reduce costs in downstream processes. Research could focus on engineering and biological principles as well as combinations of both to improve product purification.

- **Enhanced Enzymes and Chemical Catalysts –** The development of enhanced enzymes and chemical catalysts including polysaccharide degrading enzymes, chemical catalysts (i.e. fuel cells) and enzymes for efficient extraction of oils is necessary to efficiently and cost effectively turn biomass feedstocks into products fuels and power.

- **Genetically Enhanced Microbes –** The development of genetically enhanced microbes through genetic prospecting and metabolic engineering can improve the efficiency and reduce the cost of feedstock conversion, while at the same time expanding the range of natural products available.

- **System Design and Optimization –** Optimized systems like biorefineries could potentially use complex processing strategies to efficiently produce a diverse and flexible mix of conventional products, fuels, electricity, heat, chemicals, and material products from biomass. Greater research is needed to further evaluate, develop and deploy the biorefinery concept for local and regional markets. Biorefineries can become markets for locally produced biomass resources and simultaneously provide a local and secure source of fuels, power, and products.

**<u>Non-R&D Recommendations</u>**

- **Increased Coordination/Integration between USDA and DOE** - There is a need to integrate the individual strengths of USDA, DOE, and other federal agencies in pursuing a coordinated approach to biobased product and bioenergy R&D. DOE and USDA should work with industry to facilitate industry-integrated Visions and Roadmaps for bioenergy and biobased product R&D. Both agencies should work together to coordinate their bioenergy and biobased product research programs. Through its widespread outreach network, USDA should take on the role of transferring technology and technical results that develop from this collaborative research. Both agencies should concentrate their research efforts on projects with commercial partners and should make their pilot plants and production research facilities accessible to industry.

- **Bioenergy/Biobased Products Infrastructure -** There is a broad need to develop the infrastructure to effectively develop products and move them to market. This includes improved recovery, transportation, processing and manufacturing systems with the capability to produce, move and store biomass resources, and to turn biomass into valued biofuels, and biobased products while retaining feedstock and product quality.

- **Standards and Incentives** - A range of standards are needed to verify performance in the industry and to help improve marketability. These include standards for machinery and management practices, environmental quality of feedstocks and conversion technologies, and accreditation and standards for the energy content and quality of feedstocks. Similarly, incentives such as tax incentives, market pull mechanisms and equitable financial incentives for non-profits, are needed to encourage increased use of bioenergy/biobased products. Examples include: fleet standards, oxidation standards, production tax credits and federal procurement policies.

- **Market Pull Strategies –** Strategies include increasing the market demand for biomass products. Achieving these strategies will involve a cohesive and consistent long-term policy to develop and promote biobased products. This policy might include systems that acknowledge and provide benefits for waste consumption and greenhouse gas reductions.

- **Promote Joint Economic and Environmental Benefit -** Products or processes that have both economic and environmental benefits should be given greater financial priority than those that unilaterally benefit the industrial economy.

- **Enhancing the Supply of Biomass -** The land set aside by the Conservation Reserve Program and other stewardship programs, and currently overcrowded forestland could potentially be used to grow biomass for use in biopower, biofuels and biobased products. For example, some CRP lands may be suitable for harvest of perennial grasses, trees, and energy crop production while preserving soil and providing other benefits including wildlife habitat, carbon storage, and clean water.

# ATTACHMENT A:

# TECHNICAL ADVISORY COMMITTEE MEMBERS

## Attachment A
## Technical Advisory Committee Members

Larry Bean
Iowa Department of Natural Resources
Fuels Subcommittee

Robert Boeding
National Corn Growers Association
Products Subcommittee

Dale Bryk
Natural Resources Defense Council
Power Subcommittee

Robert R. Dorsch
DuPont
Products Subcommittee

Douglas Durante
Clean Fuels Development Coalition
Fuels Subcommittee - Chairperson

Glenn English Jr.
National Rural Electric Cooperative Association
Advisory Committee (POC)

Loyd Forrest
TSS Consultants
Fuels Subcommittee

Carolyn Fritz
The Dow Chemical Company
Products Subcommittee

Stephen Gatto
BC International
Fuels Subcommittee

William Charles Guyker
Allegheny Power Systems
Power Subcommittee

Ronald Ray Heck
Checkers Incorporated
Products Subcommittee

Walter Hill
Tuskegee University
Products Subcommittee

Jack Huttner
Genecor International, Inc.
Advisory Committee (POC)

Roland Hwang
Natural Resources Defense Council

F. Terri Jaffoni
Cargill, Incorporated
Fuels and Products Subcommittees

Michael Ladisch
Purdue University
Fuels Subcommittee

David Morris
Institute for Local Self Reliance
Fuels Subcommittee

William Nicholson
Potlatch Corporation
Power Subcommittee

Edan Prabhu
Reflective Energies
Power Subcommittee

J. Roger Rivera
Roger Rivera and Associates

Jefferson B. Seabright
Texaco, Incorporated

Philip L. Shane
Illinois Corn Marketing Board
Products Subcommittee - Chairperson

Holly Youngbear-Tibbetts
College of Menominee Nation
Products Subcommittee

Larry P. Walker
Cornell University
Fuels Subcommittee

John W. Wootten
Peabody Group
Power Subcommittee - Chairperson

POC = Point of Contact

# ATTACHMENT B:

# MINORITY REPORT

# BIOMASS RESEARCH AND DEVELOPMENT TECHNICAL ADVISORY COMMITTEE RECOMMENDATIONS

# MINORITY REPORT

**Submitted by**

**David Morris**
**Institute for Local Self-Reliance**

**Submitted to**

**Secretary of Agriculture**
**Ann M. Veneman**

**and**

**Secretary of Energy**
**Spencer Abraham**

**In Accordance with**
**Biomass R&D Act of 2000 (P.L. 106-224)**

**December 2001**

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**BACKGROUND**

Only a little over a century ago, ours was largely a carbohydrate economy.

In 1820 Americans used about two tons of vegetables for every one ton of minerals. Just before the Civil War grain-derived ethanol and wood-derived methanol were among the nation's largest selling chemicals. As late as 1870 about 65 percent of our energy was generated from wood. The first plastic was made from cotton; in the 1890s a later version launched consumer photography.

By 1920, the raw material foundation of the economy shifted direction. Americans were using about two tons of minerals for every one ton of vegetables. After World War II the change accelerated and by 1970 the carbohydrate economy had virtually disappeared. Vehicles used no biofuels. Electricity generated from biomass accounted for less than 1 percent of the nation's power. Almost two thirds of our fibers were derived from petroleum. Vegetable oil-based inks had all but disappeared.

And then, slowly, the pendulum began to swing back, driven by technological and political advances.

On the technological front, the biological sciences and engineering made dramatic strides, lowering the cost of producing bioproducts and biofuels. The cost of several industrial enzymes, for example, dropped by almost 90 percent from l980 to 1995.

On the political front, governments began to take into account the environmental costs resulting from extracting, manufacturing and disposing of products made from fossil fuels. Sometimes this was done by regulating fossil fuels, sometimes by offering incentives to renewable fuels.

Regulations raised the price against which renewable resources compete. Banning of non degradable plastic bags made starch and sugar based plastics more competitive. Mandatory reductions in sulfur emissions from power plants and trucks make biofuels more attractive.

The combination of technological advances, environmental regulations and public incentives has ushered in a modest reemergence of a biological foundation to industrial economies. The consumption of biofuels in vehicles rose from zero in 1977 to almost 1.5 billion gallons in 1999. Electricity generated from plant matter increased three fold between 1981 and 1997. The market share of soy inks in the U.S. more than quadrupled from 1989 to 2000, from less than 5 percent to over 22 percent.[1]

Plant matter now provides about l percent of our transportation needs, about 2 percent of our electricity needs and about 3 percent of our chemical needs.

The carbohydrate economy may be on the verge of a full scale revival. The potential is huge. In the continental U.S. alone we could grow and harvest, on a sustainable basis more than 1 billion tons of additional plant matter. That would be sufficient to completely replace petrochemicals with biochemicals or put a serious dent in our consumption of fossil fuels for transportation or modestly contribute to the nation's supply of electricity, in the process creating thousands of new manufacturing and processing facilities in rural areas.

Gradually, policy makers acknowledged that expanding the use of plants could simultaneously address several important national issues: national security, environmental protection, farmer survival and economic development. Using plant matter for industrial purposes can reduce pollution, bolster depressed rural economies, aid family farmers, and make us less dependent on oil imports from regions largely hostile to us.

In the late 1990s leaders of both political parties began to push for a more aggressive and coherent national effort to substitute carbohydrates for hydrocarbons. With Executive Order 13134 issued in August 1999, President Clinton launched a national Bioenergy Initiative, "a national partnership...to produce power, fuels and chemicals from crops, trees and wastes." Partners specifically mentioned were industry and the federal Departments of Energy, Agriculture, Commerce, Interior, the EPA and the Office of Management and Budget.

The Executive Order created a National Biobased Products and Bioenergy Coordination Office, an Interagency Council on Biobased Products and Bioenergy co chaired by the Secretaries of USDA and DOE, and an Advisory Committee on Biobased Products and Bioenergy to advise that Council.

The Executive Order established a goal: to "triple the U.S. use of biobased products and bioenergy by 2010."

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[1] For a more in-depth historical analysis and market sector analysis see David Morris and Irshad Ahmed, *The Carbohydrate Economy: Making Chemicals and Industrial Materials from Plant Matter*. Institute for Local Self-Reliance. Washington, D.C. 1992. Also see, Ahmed and Morris, *Replacing Petrochemicals with Biochemicals*. Institute for Local Self-Reliance. Washington, D.C. 1994

In April 1999, Senator Richard Lugar, then Chair of the Senate Agriculture Committee, with strong support from the current Committee Chair, Senator Tom Harkin, introduced the National Sustainable Fuels and Chemicals Act.(S. 935). The bill was intended to encourage "healthier rural economies" while making a "decisive impact on the risk of climate change" and "reducing American dependence on imported oil".

S. 935 became part of the Agricultural Risk Protection Act of 2000(PL 106-224), which became law in June 2000. Title III of that law, referred to as the Biomass R&D Act of 2000, established the Biomass Research and Development Board, co-chaired by the Departments of Energy and Agriculture and including a senior officer from the Department of Interior, the EPA, the NSF and the Office of Science and Technology Policy. A Biomass R&D Technical Advisory Committee was established to advise that Board.

Both the Board and the Advisory Committee created by PL 106-224 superseded similar bodies created, but never convened, by EO 13134. The Advisory Committee first met in December 2000.

This Committee is charged by Congress to submit an annual report to the Secretaries of Energy and Agriculture and the Biomass Research and Development Board. The majority report satisfies that charge and contains useful information. But it does not go far enough in offering concrete recommendations that will generate a productive discussion about how to fashion a coherent, cost-effective and aggressive federal policy to effect a carbohydrate economy.

**DISCUSSIONS AND RECOMMENDATIONS**

## 1. Clarify the Purview and Jurisdiction of the Advisory Committee

The Advisory Committee has been burdened by a confusion resulting from the overlap in time of EO 13134 and PL 106-224. The language of the Executive Order was broader, envisioning an advisory committee that would assist in designing and monitoring an aggressive national bioenergy initiative. The language of PL 106-224 was narrower, focusing on federal research and development expenditures, although testimony by the Act's sponsors argues that they viewed it as an important component of an aggressive and comprehensive national effort.

The confusion resulting from the overlap of EO 13134 and PL 106-224 is exemplified by the majority report's embrace of the very ambitious tripling goal of the Executive Order while concentrating almost entirely on research and development spending. The result is a disconnect between proposed outcomes and proposed strategies since the majority report concludes that public R&D will play little if any role in achieving the tripling goals.

A strict reading of PL 106-224 could lead to the conclusion that the Advisory Committee has no role at all since that Act has the Committee overseeing R&D expenditures resulting from the Act yet no money was appropriated to carry out the R&D provisions of that Act.

The majority wisely elected not to adopt this literal interpretation. As a result its report examines federal R&D in general and touches on policy questions. This is a step in the right direction but still reflects an unwillingness to provide advice and counsel that is comprehensive in its orientation and aggressive in its goals.

Congress and the White House should clarify the jurisdiction of the Advisory Committee. If they choose to have the Committee adopt a very narrow focus another Committee should be established that fulfills the need for a more comprehensive perspective.

With that said, this report begins by examining spending on research and development.

## 2. Increase the Impact of Research and Development Expenditures

The R&D budgets of Department of Energy and Agriculture with regard to biomass appear stable. Thus an important objective is to get more bang for the existing bucks.

### a. Expand performance based contracting

Performance based contracting is already being used. The large, multi-year contracts to two leading biotechnology companies for reductions in the cost of producing enzymes that break down biomass is a good example.

The new Administration has undertaken a major evaluation of existing R&D efforts in energy. In August, the report, The President's Management Agenda, the Office of Management and Budget(OMB) concluded, "We can rarely show what our R&D investments have produced and we do not link information about performance to our decisions about funding."

As a result, OMB and DOE are developing performance criteria for several applied R&D programs. These will be used to determine allocations in the FY 2003 budget for DOE.

The National Energy Plan required an analysis of the energy efficiency and renewable energy programs of DOE. That analysis has been completed although not yet made public

Performance based contracting, where metric advances in productivity or cost reduction are required as a condition for further disbursal of funds, should be expanded.

**b. Compare the effectiveness of exclusive licensing versus non-exclusive use of publicly funded research**

In 1980 Congress gave the Executive Branch permission to offer exclusive licenses to private companies to use research developed with public funds. Although Congress did not mandate that the Executive Branch adopt this strategy, much of the research in the Departments of Energy and Agriculture is now done under this arrangement. Twenty years after that practice began, the departments should evaluate whether the shift has been beneficial.

In the 1950s and 1960s evaluations of the Department of Agriculture's research programs found impressively high benefit to cost ratios. More recent studies have focused more narrowly on outcomes such as the number of patents issued or licenses granted or licensing revenue earned. There does not appear to be an analysis that compares the different strategies in terms of their effectiveness at commercializing the knowledge created.[2]

**c. Review other public R&D strategies**

In the same spirit of comparative analysis, federal agencies should evaluate various kinds of biomass-related R&D/commercialization strategies. One important example is the new uses funding by America's soybean farmers, through the United Soybean Board. We might also learn from the now-defunct Alternative Agricultural Research and Commercialization Center(AARCC). AARCC represented a more entrepreneurial approach using a venture capital model. It closed its doors two years ago and was the subject of a highly critical report by the Inspector General. That analysis provided concrete evidence of mismanagement. It did not evaluate how that entrepreneurial approach compared with traditional contracting with regard to R&D developments.

**d. Examine the cost-effectiveness of spending on genetic engineering**

Of the total federal R&D budget for biomass of about $230 million, the largest single expenditure, $33-$53 million, is devoted to genetic engineering. Within the genomic budget are two distinct research areas. One we might call "inside" genomics, that is, genetic engineering of microorganisms to improve productivity inside the manufacturing plant. The other, "outside" genomics, is the genetic engineering of plants in the field.

Spending on enzymatic advances to lower the cost of converting corn sugars into plastics is an example of "inside" genomics. Spending on redesigning corn so that it itself produces plastics is an example of "outside" genomics. Federal departments fund both

[2] See for more in-depth discussion, David Morris, *Technology Transfer and the Agricultural Research Service*. Report to the UnderSecretary of Research and Education of USDA. July 1996.

types of genomic research. They make little or no distinction between them. Yet each has a very different cost-benefit ratio.

"Inside" genomics offers dramatic benefits: a reduction in production costs of 40-90 percent, an increase in yields of several orders of magnitude, and a dramatic reduction in environmental pollution. The downside risk of "inside" genomics is very low.

The benefits of "outside" or field genomics, on the other hand, appear modest. The National Center for Food and Agricultural Policy, an industry organization strongly in favor of genetically engineered crops, released a study on the subject last April. It concluded that genetically engineered Roundup Ready soybeans, for example, have the same yield and require the same volume of chemicals to kill weeds as traditional varieties.

There is another important difference between inside and outside genomics. There is rarely an alternative biological strategy to inside genomics. When it comes to genetic engineering in the field, however, there is. For example, the publication Nature reports that in China the planting of a wide variety of breeds of rice resulted in a 94 percent reduction of rice blast, a devastating fungus that normally requires repeated applications of pesticides to control. Yields increased by 18 percent. In 1997 only a few acres were planted. In 2000 this grew to 150,000.

Finally, inside genomics does not appear to pose a risk to alternative manufacturing techniques. But outside genomics can however pose a risk to alternative farming techniques. Organic farmers worry that they will lose their organic certification if genetically engineered crops from a neighbor's field pollinate their own.

Given the scarce funding for biomass R&D, the dramatically different dynamics and cost-benefit ratios of inside and outside genomics research argue for a reallocation of resource expenditures.

### e. Take into consideration the question of scale

A proliferation of production enterprises increases experimentation and innovation and accelerates the learning curve. It also helps diversify local economies and encourages healthy competition. Some R&D techniques may be more capital intensive than others, lending themselves to a greater economy of scale. Given that one of the goals of the bioenergy initiative is to build healthy rural economies, the federal government should investigate whether an aggressive embrace of that goal would or should lead to changes in the kinds of knowledge and technologies it focuses on in its R&D program.

## 3. Accelerate Commercialization Through Policy

Publicly supported research and development efforts are important, but it is policy that drives the expansion of the use of plants for industrial purposes. In the last 20 years virtually all of the expanded use of plants for industrial purposes has been a result of public policy.

The goal of a tripling in the consumption of biofuels, for example, could well be met by 2005 as a result of the ethanol incentive, new regulations regarding sulfur reduction in diesel fuels, and the decision by 12 states to phase out the use of MTBE. The California Energy Commission, for example, recently projected that ethanol production alone would increase from about 1.5 billion gallons in 1999 to 4.4 billion gallons in 2005.

While the increased generation of electricity from biomass will not approach the tripling goal, virtually all of that increase is coming as a result of public policy changes. This includes federal requirements for the capture of methane from landfills and the recent ruling by EPA that leaking hog manure lagoons would be treated like landfills.

Policy interacts with research and development. Sometimes it reinforces existing R&D efforts, sometimes it undermines them and sometimes it makes them redundant.

For example, in the late 1980s Minnesota shifted its incentive structure to a payment for the in-state production of ethanol from an incentive for the in-state sales of ethanol. The payment applied only to the first 15 million gallons produced. The result was a proliferation of small and medium sized ethanol plants, 14 by 2001.

The proliferation of plants encouraged a proliferation of engineering firms that designed and constructed these plants. It also led to strong competition and the rapid exchange of information regarding improvements in efficiency.

### a. Strive to maximize the societal and economic benefit per acre and per ton

Sunlight and wind can be harnessed only to generate some form of energy(e.g. heat, mechanical power, electricity). But plants can be harnessed for many end uses(e.g. food, feed, textiles, paper, construction products, heat, power, chemicals, fertilizer, and soon, subsoil carbon sequestration).

The Energy Policy Act of 1992 ignored this characteristic, with predictable results. It restricted the biomass tax incentive to crops "planted exclusively for purposes of being used to produce electricity". Ten years later, hundreds of wind farms have taken advantage of the Act's identical incentive for wind energy; not one biomass facility has done so. The reason is that plants are rarely if ever grown for single product markets on long term contracts.

The competing uses of plants should make the federal government cautious about targeting incentives for one specific end product. Unfortunately, this has occurred, with an emphasis on the generation of electricity even though electricity is a low value commodity.

In the late 1990s an outbreak of pfisteria in the Chesapeake Bay area was traced to pollution caused by the flow of phosphates into the water from high concentrations of poultry manure. The state of Maryland designed a coherent program to tackle the problem, ranging from encouraging the addition of phytase to the feed to reduce the amount of phosphorous in the manure, to paying farmers to transport the manure to more attractive land areas for application, to a competitive grant program to foster new technologies.

Congress responded by expanding the biomass tax credit to include poultry manure, in essence, offering an incentive of $15 per ton of manure or litter only if the end product was electricity.

Poultry manure is an attractive organic fertilizer. Unlike hog or dairy manure, poultry manure is dry and thus relatively easy to transport and store. It is high in nitrogen. The rapid growth of the organic foods market has increased the demand for organic fertilizers since farmers cannot gain organic certification if they use synthetic fertilizers. In 1990 poultry growers paid to have someone take their manure away. Manure thus met the definition of a "waste". By 2000, however, as farmers rediscovered the benefits of natural fertilizers, in growing sections of the country poultry producers were being paid for their manure.

The Congressional incentive and similar incentives enacted by some states could displace millions of tons of high grade fertilizer. That could undermine soil health and require the manufacture of more nitrogen-rich fertilizers derived from natural gas, a very energy intensive process.

The majority report supports the concept of biorefineries. Such support is justified. A biorefinery, by definition, produces several products. One can expect that, incentives aside, businesses will strive to produce for the highest value market. If the federal government intervenes to provide incentives for lower value markets(e.g. electricity generation) it would at best fail and at worst skew technological development in harmful ways.

For example, one company has developed, with private investments, a rapid pyrolysis process to convert wood to a biooil. In the early 1990s it began selling this technology to a food additive manufacturing company. In the late 1990s, with federal financing, it successfully experimented with co-firing the biooil in a coal power plant. But the company's CEO indicated, "It is possible that in the future(we) will establish ...facilities which are l00% bio-fuel related. Nevertheless, under present market conditions, we believe that the most attractive economies are in adopting a refining approach to this industry, based on the extraction of higher value natural chemical components first, and the use of remnant bio oil and other byproducts in lower value applications such as fuels."

Given the nature of commercial development one can expect the first biological resources used to generate electricity will be waste materials: agricultural residues, feedlot manure, urban garbage, landfill wastes. Again, federal agencies should examine the second order effects of intervening as these markets develop.

In the early 1980s, for example, the federal government offered handsome incentives as well as R&D grants for the production of electricity by incinerating urban wastes. Since incinerators have significant economies of scale they tended to be oversized. Communities that built them often foreclosed less expensive disposal options(e.g. recycling).

Today federal agencies are encouraging "bioreactors", redesigned landfills that inject water to capture a larger quantity of the methane generated. Some experts worry that these incentives, like those for garbage incinerators, could skew technological development and foreclose more societally optimal options.

Incentives or publicly funded R&D for manure digesters raises similar concerns. Digesters and power generation technologies have a payback of less than 10 years. State and federal regulators appear to be moving toward requiring feedlot owners to make this investment as a way of eliminating pollution. Thus regulation may allow scarce R&D funds to be shifted to more attractive programs. This would allow the departments to be responsive to one concern expressed by the OMB in its recent report: "many R&D projects directly benefit corporations that could fund their own R&D projects without federal assistance".

Incentives for animal manure digesters, like incentives for electricity generation from poultry manure, favor a specific kind of agriculture. In dispersed animal feeding operations manure inexorably becomes a fertilizer. Concentrated animal feeding operations concentrate the manure. This creates both an environmental problem and an opportunity for electricity generation. Presumably concentrated operations have emerged because they are more economical. That would argue that they could and should pay to eliminate the pollution caused by concentration. The federal government should be cautious about providing incentives that tilt the market place toward such operations.

### b. Promote dispersed ownership

As was mentioned above, a proliferation of small and modest scaled production enterprises tends to encourage the greatest innovation, competition, and cost reductions. A significant literature indicates that it also promotes healthy communities and strong local economies.

Expanded markets for farm products do not inevitably translate into higher net income for farmers and rural communities. To achieve that farmers must receive a portion of the profits earned beyond the farm gate.

Consider the differential impact of an expanded market for ethanol on farmers who sell their corn to ethanol producers as compared to farmers who own the ethanol producer. The impact on the first is an increase in price of maybe 10 cents a bushel. The impact on the second can translate into a dividend of 25-75 cents a bushel. Indeed in 2000 many corn farmers who were shareholders in an ethanol plant received almost as much in dividends as they did for their corn, on a per bushel basis.

Today there are over 100 farmer-owned factories. All are less than 25 years old. Most are less than l0 years old. Public policy at the federal and state level could support such forms of ownership as a way of maximizing the benefit of expanding biomass markets to rural areas and the cultivators.

This can occur in a number of ways. The majority report mentions one: offering a preference to farmer owned cooperations when licensing technologies created with public financing. One could go further and require that such technologies be licensed to farmer owned cooperatives on reasonable terms.

As a result of Congressional action, the Commodity Credit Corporation(CCC) offers about $150 million a year in surplus corn and soybeans to ethanol and biodiesel producers that expand production. To its credit the CCC designed its program to provide higher incentive to smaller plants. It has the authority, although has not chosen to exercise it, to favor farmer owned biofuels plants.

## 4. Program-specific suggestions

The majority report divides the world of biomass into three sectors: biopower, biofuels and bioproducts. This division parallels the DOE program structure.

Such a division creates problems. For example, by some reports a hydrogen economy could be based on plants as its renewable resource. Where should the hydrogen R&D and commercialization efforts be housed? Some reports indicate that the most cost effective way to produce ethanol from cellulose is to make ethanol a byproduct to the manufacturing of higher value chemicals. The remaining biomass would be used to generate electricity. Such a project cuts across all three program areas.

A division of labor is necessary, of course, to run a manageable program. Given the complex nature of biomass and its multiple applications, such a division can work only if there is very close coordination and information exchange among the program areas, not only within departments but between departments.

Each program area has, we believe, a principal issue. In biofuels it is how to commercialize ethanol production from cellulosic materials. In biopower it is how to commercialize cofiring and perhaps the gasification of black liquors. In bioproducts it is how to expand the market, knowing that initially the products will be more expensive and no incentives are available. This section discusses each.

### a. Cellulose to ethanol.

As ethanol production rises toward 4 billion gallons there will be increasing pressure to make ethanol from the vast quantity of cellulosic materials available. Efforts to commercialize this process have been going on for more than 15 years. In July 2001 the Inspector General issued a critical report to the Secretary of Energy on how it has handled this program.

The vast majority of federal money for cellulose to ethanol commercialization has been focused on building a greenfield cellulose to ethanol plant. A preferable strategy might be to build a cellulose to ethanol plant on the front end of a grain to ethanol facility. The benefit of this is that the existing facility already contains the experienced management and engineering capacity necessary to oversee and market production. The front end operation would focus on pretreatment of the cellulose, breaking it into its component sugars.

The Department of Energy has a program, Building a Bridge to Ethanol, that moves in this direction. A more aggressive effort might finance three front-end facilities, each using a different technique already proven at a preproduction stage. The federal government might invest $15 million with the ethanol plant owners matching this. All technical information would be publicly available.

For a total federal investment of $45 million one could have working, commercial scale cellulose-to-ethanol plants. This would begin the sorely needed learning curve that comes from any commercialization process.

### b. Cofiring

Cofiring, that is, the addition of 3-10 percent of biomass to a coal fired power plant, has the potential to vastly expand biomass use for power generation. It is, from all studies, the least costly way to do so. Yet cofiring is still not commercial.

Various reasons have been given for this. One is that power plant owners have been unable to access significant quantities of low cost biomass in long term contracts. Another is that EPA regulations require coal fired power plants that make the investment to cofire to also upgrade their pollution control devices to meet new performance standards for new coal fired power plants. Still another is that the use of biomass changes the composition of the ash. In the last few years coal fired power plant owners have finally gained a market for the ash in the construction industry. And still another is that insufficient R&D has been done to understand the long term effects of cofiring biomass, especially agricultural residues, in power plants.

Each of these barriers argues for a different type of strategy. Some could be overcome by expanding federal tax incentives to cover cofiring. Others would require regulatory changes. Still others might require new institutional vehicles. It is unclear at present what strategy the federal government is adopting with regard to cofiring.

### c. Bioproducts--expanding a market without incentives

An important barrier to an expansion of bioproducts sales is that they are often higher priced than their petrochemical counterparts. One way to overcome this is for the government to use its vast purchasing might to favor bioproducts. Executive Order 13101 issued by President Clinton did order that bioproducts be considered environmentally preferable products. The USDA established a Biobased Products Coordination Council to develop guidelines for listing biobased products for use by Federal agencies and to develop a list. The list was never developed. Developing such a list is a complicated process and there were little financial resources available to both develop and promulgate the use of bioproducts by federal agencies.

## 5. Improve the Coordination and the Dissemination of Information

The last two administrations as well as Congress have indicated the need for more coordination among agencies working on bioenergy. The majority report includes this as an important goal.

Federal coordinating bodies are still embryonic. Turf battles, both within and between agencies still dominate. Moreover, Congressional intervention has complicated the coordination process by earmaking a growing proportion of biomass funds to specific projects.[3]

In the past earmarked appropriations tended to be added to departmental budgets. This year it appears there will be about $30 million in earmarked funds and some of these will substitute for existing departmental projects. It may be that these new projects are superior, but such a fragmented decision making process, at best, confuses and paralyzes administrators.

To accelerate the use of biomass one needs to coordinate not only between and among departments but from the farmer to the power plant or refinery and product manufacturing process and sometimes, to the final customer. This can be a very complicated process.

For example, the 2000 Agriculture Appropriations Act allowed up to 250,000 acres of Conservation Reserve Program(CRP) land to be harvested for the production of energy in up to six 10 year pilot projects. This was done to provide incentives for farmers to grow the quantities of biomass necessary to operate large scale cofiring and biomass combustion programs. Yet all six ran into bureaucratic barriers.[4]

Coordination begins with the transfer of information. Although federal departments often have superior publications, there is no one information source that tracks developments in the biomass area.

For two years the Economic Research Service(ERS) issued an excellent in-depth quarterly review of developments in the biomass sector. It would be wise to re-establish that information outlet.

Federal web pages tend to provide information only about agency services and publications. What is needed is a web page created for the purpose of providing information about biomass. Such information should be accessible, balanced and practical. Federal agencies might solicit assistance and possibly management from federal and public librarians trained in understanding how to guide searchers to the needed information, whether it be a chart, a publication, an agency phone number, a technology description or a company.



[3] Indeed, the Department of Energy responded to the Inspector General's criticism of its cellulose to ethanol commercialization program by noting that each company evaluated was the recipient of a $4 million earmarked appropriation from Congress, thereby reducing DOE's flexibility.

[4] See Sarah Hannigan, "Energy from Conserved Land", *The Carbohydrate Economy*. Fall 2001.