MOVING TOWARDS BIOMASS: CURRENT SUPPORT FOR BIOMASS USAGE IN THE UNITED STATES

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ABOUT THE AUTHOR

Jennifer Walden is entering her fourth year of undergraduate studies in Chemical Engineering at Illinois Institute of Technology (IIT). This paper was researched and written through her participation in the Washington Internships for Students of Engineering (WISE) program in the summer of 2000. The American Institute of Chemical Engineers (AIChE) sponsored her participation in this program.

THE WISE PROGRAM

The Washington Internships for Students of Engineering program is a ten-week program for outstanding engineering students who have completed their third year of study. Applicants have an interest in public policy, especially the role that engineers play in the policy process. Participants attend frequent meetings with government officials, policy makers, academics, lobbyists and other non-government individuals to learn how the government makes decisions on complex technological issues and how engineers can contribute to legislative and regulatory public policy decisions. Each student also researches, writes and presents a policy paper on a topic of interest to his or her sponsoring society. For more information visit www.wise-intern.org on the World Wide Web.

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EXECUTIVE SUMMERY

Biomass is defined as any organic matter that is available on a renewable or recurring basis. It can be used for chemicals, power and fuels. The market, once geared towards biological sources, shifted to petroleum because of the availability and low cost of fossil products in the early 20th century. However, there are many reasons to look at augmenting the use of oil with biomass. The use of biomass could benefit the United States' economy, environment, energy security and market opportunities.

Currently, there is a great deal of support for biomass in both government and industry in the United States. The Biomass Research and Development Act of 2000 detailed an integrated research effort between the DOE and the USDA. Although funding for the initiative remains relatively static, the federal agencies are actively participating in research as well as deployment efforts. These agencies are working towards tripling the use of biomass by 2010, which is a national goal established by former President Clinton.

There are many research, market and policy challenges that need to be overcome, as well as some opposition to address in the drive toward increased biomass usage. Some of these challenges are currently being explored. Detailed research is being performed, biorefineries are being built and policy matter is under consideration. Work in these areas still remains.

There is governmental activity underway to try to integrate an increased use of biomass into the market. This includes the introduction of multiple bills in Congress as well as the use of Commodity Credit Corporation funds and Conservation Reserve Program lands. These all work to provide incentives for biomass usage. Another possibility for helping to jumpstart the biobased industry could be the creation of a private sector consortium. In this way technical challenges could be cooperatively explored by industry leaders and perhaps advancement could occur more quickly.

Looking at all this, it is apparent that there is interest in the use of biomass. It should be noted that biomass will best be used as a complement to existing products and not as a total replacement. There is quite a bit of research to perform and hurdles to overcome, although an excellent start has occurred and forward progress will continue. Biomass will, without a doubt, be a part of the future industrial market.

ISSUE DEFINITION

OVERVIEW

Since ancient times, renewable resources from agriculture and forestry have been used as raw materials for countless products. However, the United States experienced a shift to fossil sources in the early 19th century with increased coal usage. At this time, fossil fuels were cheap and abundant and the market welcomed the transition. During the 1920s, most chemical producers replaced biological raw materials with petroleum. By the 1970s, petroleum accounted for 70 percent of America's fuels, and fossil fuel resources decidedly dominated the market.[1] Fossil fuels, however, are a nonrenewable resource and the International Energy Agency says that world production of oil will peak sometime between 2010 and 2020.[2] This being the case, the concept of augmenting industrial production and energy needs with the use of biobased resources is one to be strongly considered. Starting in 1999, various national activities have shown increased interest and support for biomass usage, including the presidential establishment of a national goal to triple biobased product and bioenergy usage in the U.S. by 2010[3]. The National Research Council also issued a report on Biobased Industrial Products in 2000. Another significant activity was the signing into law of the Biomass Research and Development Act of 2000. This act is designed to provide integration and direction for the research and development activities with regard to biomass and provided an authorization of $49 million for research programs.[4] All of the activity in the area of biomass is helping to open new opportunities for the United States' future in energy, fuel, and chemical production.

RELEVANCE TO THE GENERAL PUBLIC

The recently issued NRC report on biobased industrial products states, "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."[5] This impact would affect the economy, environment, energy security, and competitive position of the United States.[6]

Economy

The increased usage of biomass would stimulate economic growth, notably in rural and farm communities. Meeting the national goal set forth would provide a market for what is normally considered agricultural waste. Additionally, biorefineries set in farming communities would provide jobs and benefit industry as well. A recent Oak Ridge National Laboratories study states that bioenergy crop production programs would increase U.S. agricultural income by $6 billion per year.[7] An Economic Research Service study adds to this, stating a figure of about $250,000 in sales per job.[8] The multiplier effect goes on to say that for every primary job in manufacturing, four more jobs in service and supply are created. The NRC committee responsible for the report foresees approximately 1 million jobs in biochemicals alone.[9] These values do not take into consideration potential jobs lost in the petroleum industries and further research is necessary to evaluate possible effects.

Environment

The issue of climate change has worldwide attention right now, especially with the debate over the Kyoto Protocol. Biomass could prove to be one way to help alleviate environmental problems such climate change. Although debate persists, research has shown that the use of biomass has the potential to reduce carbon dioxide and other pollutant emissions, reduce soil erosion, protect water supplies and quality and diversify crops.

The burning of biofuels does release CO_2 into the atmosphere. However, this release is what was and will in the future be fixed by photosynthesis.[10] Thus, there is essentially no net addition of CO_2 to the atmosphere with the use of biofuels. Another environmental issue along the same lines is the attempted phase out of the use of the fuel additive methyl tertiary butyl ether (MTBE), which is now believed to threaten ground water quality. More research needs to be performed to determine what effect ethanol has on drinking water supplies.

Energy Security

The United States is becoming increasingly dependent on foreign oil imports, importing 56% of its total petroleum[11] and borrowing $1 billion per day from other nations to finance its high consumption.[12] Additionally, over two-thirds of the worlds remaining oil reserves are in the potentially volatile Middle East.[13] This dependence keeps military forces of the United States in the Persian Gulf, affects foreign policy, and gives the region a great deal of leverage. In fact, a renewed interest in ethanol was apparent in the 1970s, when oil supply disruptions in the Middle East became a national security issue.[14] The Persian Gulf crisis in the early 1990s continued to support investigation into other sources of fuels as well. Ethanol advocates Senator Richard Lugar (R-IN) and R. James Woolsey believe that increased usage of bioproducts and biofuels could greatly benefit the U.S. by reducing our dependence on foreign oil.

Competitive Position

Products from biomass could open up new technologies, industries and export opportunities for the United States. The 1994 Uruguay Round and the World Trade Organization are helping to increase access to international markets and establish new rules for freer trade.[15] If the U.S. works to become a technological leader in the biomass market, it could capture an important market share and lead in some important intellectual property areas. Other countries involved in significant biomass research include Austria, Canada, Germany, Japan, the Netherlands, South Africa and the United Kingdom.[16]

RELEVANCE TO AICHE

As a professional association of more than 50,000 members, the American Institute of Chemical Engineers works to provide leadership in advancing the profession of chemical engineering. The membership of AIChE spans academia as well as many areas of the private sector. Thus, an increase in biomass activity is sure to affect AIChE, as the organization fosters and disseminates relevant knowledge, supports the professional and personal growth of its members, and applies the expertise of its members to address societal needs throughout the world.[17] As an organization AIChE

advocates public policy that represents the interests of chemical engineers. Biomass is one such area that AIChE should find relevant and timely.

BACKGROUND

DEFINITION OF BIOMASS

The definition of biomass as used in the wording of the Biomass Research and Development Act of 2000 is as follows:

> *Biomass is any organic matter available on a renewable or recurring basis, including agricultural crops and trees, wood and wood waste and residues, plants (including aquatic plants), grasses, residues, fibers, and animal wastes, municipal wastes, and other waste materials.*[18]

To demonstrate the availability of biomass, the United States disposes of approximately 350 million tons of agricultural wastes each year.[19] Much of this waste could potentially be converted to ethanol or any number of other products.

USES FOR BIOMASS

In the early 20th century plant matter was providing the basis for most industrial products, including dyes, chemicals, clothing, and plastics. However, fossil products became plentiful and production methods using oil were cheaper. Fuels and products from oil became available in large quantities at low cost, and, by the 1970s, petroleum had taken over the market[20] phasing out plant matter usage. With the current push to supplement the use of petrochemicals, however, there are many potential uses for biomass in today's market. The three categories most commonly used for grouping are biofuels, biochemicals, and bioenergy.

Biofuels

Ethanol is a clear, colorless, flammable fuel, predominantly coming from the fermentation of corn starch. Ethanol can be blended with gasoline for vehicular use and is also being looked at to power fuel cells. Approximately 56 fuel ethanol plants exist in

20 states, with production capabilities ranging from 0.5 million gallons to 310 million gallons per year.[21] The cost of ethanol production has decreased from $3.60 per gallon in 1980 to $1.27 per gallon in 1991 and should continue to decrease with improved technology.[22] The use of cellulosic biomass (virtually any plant or plant products) as a source for ethanol production could reduce costs even further and perhaps provide a major market niche.

Biodiesel is made using plant oils and methanol to produce fatty acid methyl esters. Oils that can be used include soybean, canola, industrial rapeseed, and even used vegetable oil. In 1998, Congress passed legislation classifying biodiesel as an alternative fuel under the Energy Policy Act of 1992. EPACT mandates that federal, state, and some private fleet acquire alternatively fueled vehicles.[23] Now, soy-based biodiesel is currently being used by more than 80 fleets nationwide,[24] and in May of 2001, the first pure biodiesel public fueling station opened in San Francisco.[25] Biodiesel can be used in diesel engines without negative impact, an important quality,[26] although blended fuel is reportedly better for use.

Biochemicals – Intermediate and Specialty

Intermediate chemicals are utilized to produce paints, plastics, solvents, synthetic fibers and the like. Ethylene, the most versatile petrochemical, can now be produced using lignocellulose conversion technology. However, the biobased ethylene that results from this process is not cost competitive at the present time. Stable production cost may allow it to compete with the rising petrochemical ethylene cost within the next five years, however, assuming the continued rise of oil and gas prices.[27] Acetic acid is another intermediate chemical that could be targeted by bioindustry for a multitude of uses. Fermenting corn starch or cheese whey waste produces acetic acid. Used for soaps and lubricants, fatty acids such as esters, ethoxylates and amides can readily be produced from plant oils. In 1991, forty percent of the 2.5 million tons of fatty acids produced in the United States were derived from vegetable and natural oils.[28] This market share could hopefully be expanded.

Specialty chemicals are a high value market, generally selling for more than $2.00 a pound. Annual sales exceeded $3 billion in 1994 and the market for specialty

chemicals is expected to continue to grow at a 10 to 20 percent per year rate.[29] This market has been tapped, with examples of biobased chemicals including bioherbicides, thickening agents, flavors, fragrances, chiral chemicals and enzymes. The growing enzyme market is one already dominated by biological material fermentation and will continue to do so.

Bioenergy

The United States currently receives only 3 percent of its heat and electric power needs from biomass residues, municipal wastes, and landfill gas.[30] After hydropower, biomass ranks second in renewable energy. Multiple technologies exist for using biomass as energy. Biomass can be burned directly, generating steam for electricity production. Biomass can also be used as a supplement to coal in coal-fired plants in an effort to reduce emissions. Gasification of biomass also allows for its use as an energy source. During the past 20 years, 730 bioenergy electric-generating facilities have been built.[31] Increased use of combined heat and power (cogeneration) systems, where heat and electricity are generated simultaneously, will continue to help bioenergy become more competitive. Cogeneration systems have higher efficiencies and lower emissions than traditional technologies.[32] Legislation is currently underway in the 107th Congress supporting CHP facilities. Additionally, President Bush's *National Energy Policy* points out that anywhere between 60 to 90 new power plants will be needed in each of the next 20 years to meet an increased demand.[33] Biomass could be used in a number of the new plants that will be developed.

LEGISLATIVE HISTORY OF BIOMASS RESEARCH AND DEVELOPMENT

Prior to 2000, biomass and its multiple uses were being considered on many fronts. The Department of Energy and the Department of Agriculture were funding research and projects. Universities and industry were active participants. Legislation had been passed that dealt with biomass related issues. Biomass was definitely not something new.

Biomass received a much-needed endorsement, however, on August 12, 2000 with the release of President Clinton's Executive Order 13134, titled "Developing and

Promoting Biobased Products and Bioenergy." The executive order established a permanent council to develop a detailed biomass research program focused on "research, development, and private sector incentives to stimulate the creation and early adoption of technologies needed to make biobased products and bioenergy cost-competitive in national and international markets."[34] This plan was to be reviewed by an outside advisory group composed of representatives from industry, academia and environmental interests. The council was also instructed to review the effectiveness of major agency regulations, incentives and programs and to establish a coordination office for biobased products and bioenergy. In addition to issuing this Executive Order, President Clinton also declared a goal for the United States to triple its use of biobased products and bioenergy by 2010. The participants in the biomass sector look to achieve this goal.

Meanwhile, biomass was becoming an issue in Congress as well. Senator Richard Lugar (R-IN), the former chair of the Senate Committee on Agriculture, Nutrition and Forestry, is a strong supporter of biomass usage. This is shown in his co-authoring of "The New Petroleum" with R. James Woolsey. This article, published in early 1999, heavily supports ethanol as a replacement for petroleum. On April 30, 1999, Senator Lugar sponsored S.935, the National Sustainable Fuels and Chemicals Act of 1999. This bill had strong bipartisan support and passed the Senate by unanimous consent. After being sent to the House for consideration, S.935 was incorporated into H.2559, sponsored by Representative Larry Combest (R-TX). On May 25, 2000, both the Senate and the House of Representatives passed H.R. 2559, the Agricultural Risk Protection Act of 2000. The legislation contained four of Lugar's initiatives, including the Biomass Research and Development Act of 2000. President Clinton signed H.R. 2559 on June 20, 2000, becoming Public Law 106-224.[35] This legislation effectively replaced Executive Order 13134.

BIOMASS RESEARCH AND DEVELOPMENT ACT OF 2000

THE LEGISLATION

The Biomass Research and Development Act was included as Title III within the Agricultural Risk Protection Act of 2000. In the legislation, Congress found that converting biomass into biobased industrial products offers "outstanding potential for benefit to the national interest."[36] This being so, the main purpose of the act is to integrate the Department of Energy (DOE) and Department of Agriculture's (USDA) biomass research efforts. This integration attempts to avoid duplicated efforts while accelerate progress in research and development (commonly referred to as R&D). "The purpose of the cooperation and coordination shall be—

1. Understand the key mechanisms underlying the recalcitrance of biomass;
2. Develop new and cost effective technologies that would result in large-scale commercial production of low cost and sustainable industrial products;
3. Ensure the development of industrial products enhances economic, energy security and environmental benefits;
4. Promote the development and use of agricultural and energy crops for conversion."[37]

The legislation also detailed the establishment of a Biomass R&D Board, a Biomass R&D Technical Advisory Committee, and a Biomass R&D Initiative. These replaced their counterparts created through Executive Order 13134. The full responsibilities of the committees and offices will be covered in more detail further in the report. The Biomass R&D Act is an authorization act, requesting for $49 million each year for the USDA from 2000 through the end of 2005.[38] The authority of the act will terminate on December 31, 2005.

ORGANIZATION OF THE BIOMASS RESEARCH & DEVELOPMENT INITIATIVE

The Biomass R&D Initiative was established by H.R. 2559, which later became Public Law 106-224. It is the multi-agency effort to coordinate and accelerate all Federal biomass research and development by awarding grants, contracts and financial assistance to eligible entities. Eligibility and grant usage are defined, as are technology transfer requirements. The participating agencies in the Initiative include the Department of

Energy; the Department of Agriculture; the National Science Foundation; the Environmental Protection Agency; the Department of Interior; the Office of Science and Technology Policy; the Department of Commerce; the Office of the Federal Environmental Executive; the Office of Management and Budget; the Department of the Treasury; and the Tennessee Valley Authority. These agencies have varied involvement in the Initiative, ranging from dealing with tax credits to recycling to environmental regulation. The National Coordination Office, staffed by the DOE and USDA, manages the Initiative and serves as the executive secretariat for the Biomass R&D Board.

Two groups guide the initiative, one of which is the Biomass Research and Development Board. The Biomass Board is a cabinet level council, co-chaired by the USDA Undersecretary for Research, Education and Economics and the DOE Assistant Secretary for Energy Efficiency and Renewable Energy. Senior level designees from the above-mentioned participating agencies occupy the other positions on the board. The official functions of the Board are to coordinate programs within and among governmental agencies that promote the use of biobased industrial products, coordinate research and development activities, and to provide recommendations concerning administration of the Act. As instructed by Congress in the legislation, the Board released a strategic plan entitled *Fostering the Bioeconomic Revolution in Biobased Products and Bioenergy* in January of 2001. The strategic plan details not only technology goals, but market and public policy goals as well. Looking at policy and market issues, however, expands beyond the research confinement of the legislation. The specific goals were designed with the national goal of tripling usage in biobased products and bioenergy in mind.

The Biomass Research and Development Technical Advisory Committee[1] also helps guide the Initiative. The Committee's official functions include advising the Board concerning technical focus and direction of proposal requests as well the procedures for

[1] The Biomass R&D Technical Advisory Committee includes members from the following organizations: Iowa Department of Natural Resources/Governors' Ethanol Coalition ; National Corn Growers Association; Natural Resources Defense Council; Dupont; Clean Fuels Development Coalition; National Rural Electric Cooperative Association; TSS Consultants; The Dow Chemical Company; BC International; Allegheny Power Systems; Farm Corporation - American Soybean Association; Tuskegee University; Genencor International, Inc.; Union of Concerned Scientists; Cargill, Inc.; Purdue University; Institute for Local Self Reliance; Potlach Corporation; Reflective Energies; National Hispanic Environmental Council; Texaco; Illinois Corn Growers Association; Cornell University; Peabody Group; College of the Menomiee Nation.

reviewing and evaluating the proposals. The Committee also serves to facilitate partnerships between State and Federal agencies, agricultural producers, industry, consumers and the research community concerning biomass programs and also evaluates such program activities. Quarterly, the Committee holds public meetings, the most recent on June 11, 2001. Committee recommendations are currently being developed and should be delivered in early August.[39]

CURRENT APPROPRIATION STATUS

As previously mentioned, the Biomass R&D Act was an authorization act requesting $49 million for the USDA. This money was not allocated in the FY2001 appropriations, and the USDA's funding remained relatively constant at $112 million.[40] At the same time, however, the appropriation's Subcommittee on Energy and Water Development, increased the funding of the DOE's Biomass/Biofuels Energy Systems from $69.379 million in FY2000 to $86.268 million in FY2001.[41] This represents a 24.3% increase in the DOE's budget for biofuels and bioenergy. The entire budget, including the Biomass/Biofuels Program, for biomass research and development programs with the DOE's Office of Energy Efficiency and Renewable Energy went from $100 million to $118 million over the same year, although $18 million represented earmarks added to the bill.[42] The $18 million overall increase was intended for the integrated Biomass Initiative, yet only an estimated $5.8 million was available due to the earmarks.[43] The total appropriated joint R & D budget for the DOE and USDA for FY2001 was $230 million.[44]

The DOE and USDA individual program budget requests remain relatively constant for Fiscal Year 2002. Senator Lugar, however, is again requesting $18 million for an integrated R&D program.[45] By making the budget request for the Biomass Initiative into a separate appropriations line item, it could be protected from losing its funding to earmarks as it did the year before. The FY02 budgets have yet to be decided.

Beginning in FY2003, Senator Lugar foresees an appropriation request of $49 million for integrated Initiative, the funding target contained within the Biomass R&D Act of 2000.[46]

DEPARTMENT OF ENERGY INVOLVEMENT

Prior to the Biomass Research and Development Act of 2000, the Department of Energy was already involved in the area of biomass. The passage of the legislation served to validate the work that had already been done, while giving continued future support.[47] The DOE runs its biomass programs through the Office of Energy Efficiency and Renewable Energy. Research is focused on all three major areas, biofuels, biopower, and biochemicals. DOE works with other Federal agencies as well as with private entities in conducting its research and encourages commercialization of developed technologies. The Department of Energy also provides support to a state and local level alliance that is focused on overcoming obstacles in the path of biofuel usage.[48]

UNITED STATES DEPARTMENT OF AGRICULTURE INVOLVEMENT

The US Department of Agriculture has also been involved in biomass R & D for quite some time before the passage of P.L. 106-224. The Agricultural Research Service is the USDA's in-house research arm and develops new and advanced technologies to convert plant components to new products through its programs.[49] The ARS partners with private industry in development of products. The Cooperative State, Research, Education, and Extension Service (CSREES) links the USDA to academia and also helps to promote biomass R & D, focusing on basic and applied research and product development. Additionally, the Forest Service researches bioproducts and bioenergy development as well.

KEY CONFLICTS, CONCERNS, AND CHALLENGES

RESEARCH CHALLENGES

For biobased products to become part of the market economy there are still many research challenges to overcome. These research issues are what the Biomass R&D Act aims to remedy with its integrated approach towards biomass. The specific wording of the act asked for research to be directed towards overcoming the recalcitrance or resistance of biomass specifically regarding feedstock pretreatment and hydrolysis,

enzyme development, and new technologies other than enzymatic hydrolysis.[50] Other areas of research emphasized in the legislation are product diversification, economic reliability, and increased productivity. Research challenges can thus be broken down into three main categories: feedstock and feedstock handling, conversion, and utilization.

Feedstock and Feedstock Handling

Research on the yield, cost and infrastructure of feedstock or source of biomass is essential for the further development of biobased products. Cost reductions have the potential to occur if genetically engineering the source plants is allowed to expedite processing. The harvesting and transportation of feedstocks are also important research issues. One of the more substantial issues hindering biomass is its bulkiness and difficulty of transport. Biomass is relatively unwieldy regardless of the source, making it difficult to transport long distances to production facilities. Research in this area would be beneficial. Idealistically, research could produce the ideal feedstock that easily converts and is lightweight and transportable, removing significant barriers.

Conversion

Research into the efficiency, cost and reliability of conversion methods is necessary as well. Improvements in pretreatment technology, enhancing enzyme accessibility, could lower the economic barriers to commercial lignocellulose conversion.[51] A breakthrough in this area could drastically increase production in biomass areas. Transgenic microorganism research could benefit conversion barriers as well.

Utilization

The utilization of biomass as fuels, chemicals and electrical energy could still be researched. This would include potential new products for a biomass industry. For example, advanced bioreactor concepts could increase productivity of products, reducing capital costs. Further research into cogeneration facilities could make the use of biomass extremely worthwhile as increased utilization could help to reduce waste.

MARKET CHALLENGES

For a shift to increased biomass usage to occur and be successful, there are distinct market challenges to overcome. Currently, the market is dominated by a well-established and profitable petroleum industry. Strong incentives will be needed to entice petroleum firms to invest in a riskier market. Supply and demand, capital costs and investment options, replacement costs of facilities and infrastructure, price, quality and availability of power and fuels, as well as regulatory barriers are all issues for consideration. Incentives for companies to venture into this market are slowly being developed and some development into bioindustry is happening, as shown by increased number of biorefineries being built today. Consumer demand is another market challenge to take into consideration. If the consumer market isn't accepting of biobased products there is little reason to pursue the issue.

Biorefineries

The biorefinery concept is similar to that of a petroleum refinery. A biorefinery would process its biobased feedstock into multiple products. Doing this efficiently and at large-scale capability will be the key to making biorefineries competitive, as products would include those manufactured by petroleum refineries as well as those that petroleum refineries are unable to produce. Known and potential biorefinery products include the following:

- Fermentation feedstocks (starch, dextrose, sucrose, cellulose);
- Food products (oil, starch, sweeteners);
- Nonfood industrial products (loose fill packing material, adhesives);
- Chemical intermediates (lactic, acetic, citric, and succinic acids);
- Fuels (ethanol, acetone, butanol);
- Solvents (ethanol, acetone, butanol, esters);
- Industrial enzymes; and
- Biodegradable plastic resins.[52]

There are highly integrated biorefinery prototypes in the United States currently processing agricultural and forestry materials into marketable products. These include wet and dry corn milling plants, soybean processing plants, wheat mills, and paper mills.

Since biorefineries rely on sustainable, domestically-produced raw materials, such facilities hold potential advantages over traditional petroleum refineries. The following table compares the two refinery types.

Table 1. Comparison of Biorefineries to Petroleum Refineries.

Aspect of Comparison	**Biorefineries**	**Oil Refineries**
Impact on primary producers	Benefits U.S. farmers	Benefits U.S. and foreign producers
Impact on primary processors	Benefits U.S. processors	Benefits U.S. and foreign refineries
Impacts on other users	Gives food, fuels, pharmaceuticals, specialty and commodity chemicals producers more options at potentially lower prices.	Status quo
Technical stage	Early, room for tremendous improvement	Mature, not much room for improvement
National security	Less dependence on foreign feedstocks	Greater dependence on foreign feedstocks
Export potential	Potential to export more finished goods from domestic resources	Increases import of primary and finished goods
Environmental effects	Largely positive to neutral	Many negative

Courtesy of *Biobased Industrial Products: Priorities for Research and Commercialization,* National Research Council.

Increasing the use of biorefineries will take some time, considering the technical and financial effort that will be required. Looking at lessons from oil refinery experience will be beneficial to the future development of biorefineries. These lessons include the realization that refineries produce more and more products from the same feedstock over time and are flexible and can shift outputs in response to change. Also, processes improve incrementally over time and this improvement invariably makes the cost of raw material the dominant factor in system economics.[53] Thus, economic and technical performance of biorefineries are expected to improve with time. Even so, many supporters admit that competing with fossil products on only the basis of price will likely never be successful.[54]

Realizing the potential available in biomass, several American companies are starting to explore the possibilities of biorefineries. Cargill Dow LLC, a startup company seeded by Cargill Incorporated and the Dow Chemical Company, is building a $300-

million manufacturing facility, touted as the first biorefinery, in Blair, Nebraska.[55] Scheduled to be operational by November 2001, the Cargill Dow facility will be capable of producing 140,000 metric tons per year of polylactide (PLA) polymers from corn sugar, although any starch could be used as the initial feedstock.[56] Cargill Dow claims that PLA competes on price and performance with nylon, polypropylene, polyethylene, and cellophane as well as with natural materials such as wool, paper and cotton. PLA is a product unavailable from oil refineries, however, and is being marketed as an alternative to other products. This supports the fact that competing head-to-head with petroleum refineries on identical products is not economically feasible at this point in time. Cargill Dow will not start up the manufacturing facility using biomass. Instead they will use more expensive corn sugar. The company plans on back integrating and exploring novel process to attain the capability to use cheaper feedstocks than dextrose. The rate of back integration will depend on technological advances and reduced risks for investment.[57]

Other companies have begun to follow the lead from Cargill Dow's investment in R&D and the startup cost of the PLA facility and stepped up work on their own bioprocesses. DuPont, already a leader in the bioprocessing area, continues to invest in R&D, funding about a dozen projects in an alliance with the Massachusetts Institute of Technology.[58]

Market Pull

Just having industry producing bioproducts in refineries will not be sufficient to competitively move into the market. There also needs to be consumer interest and demand in order for successful integration to occur. As consumers become more "green" oriented, interest in biomass will increase. Even so, if products are priced too high, even the "earth friendly" marketing scheme may hit a significant hurdle. It is important to develop a market pull for bioproducts. It makes more sense to create and produce products that are desired rather than try to flood the market with something that has little interest backing it. Biobased products and bioenergy must be marketed on the merits of life cycle costs, environmental attributes and product performance in order to develop a market pull.[59] Further research into these key selling points needs to be performed, however, to accurately assess potential benefits over petroleum products. Education

about potential benefits of bioproducts will be important in creating any kind of market pull. For greatest success, this should be done on three fronts: K-12 education, consumers, and colleges and universities.[60] By developing market-driven products, assessing the merits of such products, and educating the public of these merits, consumer barriers to bioproducts could be overcome.

POLICY CHALLENGES

If biomass is going to become more widely used, there are important policy challenges to be dealt with as well. These include, but are not limited to, tax treatments for sustainable technology, environmental regulation, climate change, rural economic development, and government procurement.

Tax Treatments

The development of a biobased industry could be facilitated by tax abatement and investment tax credits. Since 1992 a "closed loop" tax credit has existed for biomass which applies only to those who grow crops specifically to be burned for energy production. Since this provision is so restrictive essentially no one has used the credit. A more appealing "open loop" rule would allow electricity producers to get the tax credit for using any kind of organic material in their production processes. Although the corn sector already receives a tax credit, further legislation in this vein would provide a needed incentive to gain more industry involvement in both research and important deployment of technologies.

Environmental Regulation and Climate Change

Most environmental regulations typically don't distinguish between fossil based and biobased products.[61] This is a definite policy challenge that needs to be explored further as it could potentially cause industrial setbacks. Furthermore, although some advocates tout biomass as the remedy to most environmental problems, it is arguably not the absolute or only solution. In fact, some studies show that low-level blends of ethanol and gasoline can even worsen air pollution. This is due to the high vapor pressure of mixtures that do not generally occur at the 22% blend level or above.[62] Currently

however, most blends are well below that percentage, even with required ethanol contents. Obviously there are many environmental issues to still be considered when looking at biomass usage in the market in order to make the best policy decisions.

Rural Economic Development

Increased usage of biomass could be very beneficial to the rural economy. Recently, Congress has passed emergency assistance packages for farmers because of low commodity prices. In 2000, direct payments to farmers reached an all time high of $22.1 billion, a value that constituted 39% of total farm income.[63] By creating a market for crops for biomass usage, these direct payments could be replaced and commodity prices increased. Similarly, over 60 million acres of land are idled each year for conservation and other purposes. If mown grass from just half of this land was used for ethanol production it could fulfill about 25% of the country's annual gasoline needs according to some advocates.[64] Making a shift from direct payments, however, could represent a significant policy barrier, as changing from the status quo can be difficult.

Government Procurement

One way to make biobased products more competitive is continued federal support of research. However, how much governmental support will be received is a matter for question. The *National Energy Policy* released by the Bush Administration in May 2001 supported biomass as a renewable source for energy. The energy policy supports the extension and expansion of tax credit for biomass technology. It is important to note that even while supporting biomass, the President's policy strongly emphasizes the necessity of more oil exploration and drilling. This even goes so far as to suggest using the bid bonuses from the leasing of the Arctic National Wildlife Refuge for funding research into alternative and renewable energy sources, including biomass.[65] This has been seen by some, especially Senate Democrats, as an "obvious attempt to defuse opposition" to the opening of ANWR.[66] The Bush plan also sets no definitive targets for biomass energy contribution, showing a possible retreat from the national goal of tripling usage of biomass by 2010. In fact, there are estimates that in order to meet the national goal it would take a tripling of funding in R & D, increasing to between $600

million to $1 billion per year.[67] If this is the case, it will be near impossible to meet the national goal with funding at its current levels. The table below outlines National Research Council targets and possible achievable levels.

Table 2: Production Targets for a National Biobased Industry.

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%

Courtesy of *Biobased Industrial Products: Priorities for Research and Commercialization,* National Research Council.

It is very unlikely as to whether research and development of biobased products would be able to be sustained without the support and funding of the government. Cargill Dow has been quoted as saying that government funding came at a "critical time" during its fundamental PLA research when financial pressure was bringing a halt to research. Although the $2 million funding represented only 1% of total research dollars, it helped Cargill Dow "stay alive and accelerate commercialization."[68] Government funding helps by providing dollar for risky research and development that would possibly not be spent otherwise. Furthermore, industrial research estimates the relative cost of discovery, scale-up and commercialization are 1:10:100.[69] This shows that any government investment in research still must be met with large investments from industry in order to bring any product to consumer availability.

POSSIBLE OPPOSITION TO BIOMASS USAGE

Food versus Fuel

One of the key selling words for a biobased industry is "sustainability." However, opposition to biomass exists doubting the potential of becoming a truly sustainable environment. Looking at historical attempts at sustainability shows an overuse of resources and subsequently erosion, desertification and loss of major food species.[70] Thus maintaining an adequate food supply could be an issue with biomass usage. Even if the current population growth rate were to remain unchanged, a larger

supply of food would be required in the future. Therefore, concern exists that if large amounts of arable land were used for biobased purposes, food shortages could occur.

Using the "World Food-Needs" model, which assumes a 100-percent rice diet of 2700 calories per day, an estimated 3 billion tons of grain needs to be produced to supply the current world population of 6 billion.[71] This production would require between 0.7 billion hectares, an optimistic approach, to 1.5 billion hectares. The value of 1.5 billion hectares represents exactly the amount of arable land in the world. This means that, by this estimate, there is barely enough land at the current time. Even with its most optimistic approach, the "World Food-Needs" model estimates that 2070 will be the latest point at which land availability will be greater than needed for adequately feeding the world population.[72]

Even the supporters of the "World Food-Needs" model admit that there are some possible ways to alleviate this problem. Research into increased productivity and yield of food crops would be beneficial. The most important area for research will be into the conversion and use of cellulosic biomass, the residues of food and fiber production. Sugars and proteins, two important nutrients, freed up in the conversion could be used for food energy.[73] Additionally, crops for cellulosic biomass such as grasses or legumes could be grown in the winter so as not to disrupt primary crop growth. This could create a soil depletion problem, however, and is a subject for further research.

Environmental Opposition

Environmentally, as with many issues, biomass usage has both positive and negative potential aspects. Thus it becomes important to decide how to weigh different environmental concerns against each other. Obviously, sorting out the environmental issues surrounding biomass is complicated. When looking at global warming, biomass can be potentially beneficial by reducing emissions. However, when looking at crop cultivation issues, biomass is very chemical intensive, requiring pesticides and fertilizers, and can add to run-off problems.[74] Also looking at potential negatives of biomass, there is a possibility to destroy habitats and endanger animal populations with insecticides. Furthermore, ethanol can cause an increase in smog during warmer weather because of low vapor pressures. Thus, when considering biomass, the Environmental Protection

Agency works to "maximize environmental benefits" through its regulation and actions.[75] In biomass as in most things, the EPA hopes that in the long run the positive benefits will outweigh the negative ones. Thus while supporting biomass R & D efforts, it is still important to consider regulatory issues as the environment can possibly be affected negatively. It is in this way that environmental opposition to biomass usage can be effectively dealt with.

Petroleum Industry

The petroleum industry does not oppose research and development of biomass usage outright. In fact several oil companies own large tracts of land and are participating in research themselves.[76] The National Petrochemical and Refiners Association (NPRA) supports allowing viable alternatives to petroleum into the market and creating healthy competition.[77] However, the NPRA doesn't favor either mandates or subsidies that could potentially give biomass products, i.e. ethanol, a market advantage. The organization believes that products should be able to "make it on their own" without being given special patronage.[78] The NPRA supports judging oxygenates based on performance standards instead of creating restrictive mandates. When discussing research issues surrounding biomass, it is suggested that research should be performed mostly in industry, although support from the government in the early stages is not opposed. Additionally, again not opposing biomass R & D, the NPRA does believe there to be a reasonably fair amount of oil remaining in less than conventional reserves around the world[79] and doesn't appear to foresee an oil shortage any time in the near future. Therefore, it appears as though biobased products could serve to augment petroleum based products in the future without serious opposition from the oil industry. However this would only be true if such products are able to break competitively into the market without special assistance.

RECENT POLICY ISSUES UNDER CONSIDERATION

CURRENT LEGISLATION IN THE 107TH CONGRESS

S.249 - Renewable Energy Development Incentives Act

This bill amends the Internal Revenue Code of 1986 to expand the credit for electricity produced from certain renewable resources. It was sponsored by Senator Harry Reid (D-NV) and has been referred to committee.

S.596 - Energy Security and Tax Incentive Policy Act of 2001

This bill amends the IRS Code of 1986 to provide tax incentives to encourage the production and use of efficient energy sources. It was sponsored by Senator Jeff Bingaman (D-NM) and has been referred to committee.

S.670 – Renewable Fuels Act of 2001

This bill amends the Clean Air Act to eliminate methyl tertiary butyl ether from the U.S. fuel supply and to increase production and use of ethanol. It was sponsored by Senator Thomas Daschle (D-SD) and has been referred to committee.

S.756 – Growing Renewable Energy for Emerging Needs (GREEN) Act

This bill amends the Internal Revenue Code of 1986 to extend and modify the credit for electricity produced from biomass. It was sponsored by Senator Charles Grassley (R-IA) and has been referred to committee.

S.933 – Combined Heat and Power Advancement Act of 2001

This bill amends the Federal Power Act to encourage the development and deployment of innovative and energy efficient technologies. It was sponsored by Senator James Jeffords (I-VT) and has been referred to committee.

COMMODITY CREDIT CORPORATION FUNDS

The United State Department of Agriculture recently made available Commodity Credit Corporation funds available to eligible producers of biofuels. For both FY2001

and FY2002, $150 million was provided to be incentive payments to producers that increased production of biofuels from the former year.[80] In FY2001, fifty-four agreements were made which accounted for 79 plants in 19 different states.[81] Future CCC agreements have been signed projecting a possible increase of production of 246.2 millions gallons of ethanol and 36.5 million gallons of biodiesel.[82] Future funding of this program could help to continue to increase biofuels production in the near future.

CONSERVATION RESERVE PROGRAM LANDS

Another recent USDA program is that of the Conservation Reserve Program. The USDA is soliciting proposals to use the CRP lands for pilot projects that use harvested vegetation for energy production. Currently seven proposals have been received and are under evaluation while four have been approved in Iowa, Minnesota, New York and Pennsylvania.[83] The vegetative cover of the CRP lands must be approved for use in the program and the total acreage per project cannot surpass 50,000 acres. Currently the maximum acreage for all pilot projects combined can not exceed 250,000 acres.[84] If the CRP land usage were expanded, the production of biomass feedstock could be greatly increased.

SUPPORTING PRIVATE SECTOR CONSORTIA

One way to support the development of a biobased industry would be to authorize the creation of a private sector consortium. This would be similar to Semiconductor Manufacturing Technology (SEMATECH), the semiconductor research consortium founded in 1987 in an effort to focus on technical challenges and make the United States competitive in the industry. Industry participants contributed research dollars which were matched by government funds for the first eight years after which SEMATECH was privatized. This public-private partnership is hailed as a success and could provide a model for a biobased industry.[85] Different areas of expertise could be brought together and given an incentive for involvement and cooperation. Congressional support and passage of legislation would be necessary for a biobased industry consortium to be created.

CONCLUSIONS

The use of biobased products as energy, fuel and chemicals is not new or previously unexplored. In the early 20th century, the availability and low cost of fossil products, however, shifted the market towards petroleum, where it remains today. There are many reasons to look at augmenting the use of oil with biomass in the future. The use of biomass could benefit the United States' economy, environment, energy security and market opportunities. Right now in fact, there is a great deal of support for biomass, especially in research and development. The Biomass Research and Development Act of 2000 detailed an integrated research effort between the DOE and the USDA. Although funding for the initiative remains relatively static, the federal agencies are actively participating in research as well as deployment efforts. In order to effectively introduce biomass into the United States economy there are many research, market and policy challenges that need to be overcome as well as some opposition to handle. Currently some of these challenges are being explored, but work in these areas still remains. Policy is underway, however, to try to integrate an increased use of biomass into the market. This includes the introduction of bills in Congress and the use of Commodity Credit Corp. funds and Conservation Reserve Program lands, all of which may provide incentives for biomass usage. Another ideal that may help to really get the biobased industry going could be the created of a private sector consortium, where technical challenges could be cooperatively explored by industry leaders.

From all this, it is apparent that there is interest in the use of biomass, and much is being done to facilitate advancement in this area. It should be noted that biomass will best be used as a complement to existing products and energy, not as a total replacement. The industry still has quite a bit of research to perform and hurdles to overcome. With everything that is currently going on in the area of biomass right now, an excellent start has occurred and progress will continue to be made. Biomass will without a doubt be a part of the future industrial market, helping to provide power, fuels and chemical products.

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