Cultivating a New Rural Economy

Assessing the Potential of Minnesota's Bioindustrial Sector

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ABOUT IATP
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ABOUT THIS PUBLICATION
Cultivating a New Rural Economy: Assessing the Potential of Minnesota's Bioindustrial Sector

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Executive summary

Minnesota's agricultural and forestry sectors have provided the historical foundation for the state's economic development and continue to supply a significant percentage of jobs, income and goods. These sectors produced most of the energy and inputs for the economy prior to the 20th century, when fossil fuels overtook bio-based products as the primary fuel and materials source. With the introduction of low-cost fossil fuels, Minnesota farmers and agribusiness succeeded in capturing new markets throughout the world. However, the recent emergence of low-cost producers of grains, oilseeds and lumber in Brazil, China, Russia and other countries has limited further growth in new markets. This has contributed to depressed commodity markets and many rural communities in Minnesota struggling to find an economic niche.

Concurrent with the stagnation of export agriculture has been the emergence of a new bio-based economy. New technologies now allow Minnesota farmers to not only keep people fed, but also to provide their electricity, fuel their automobiles, construct their homes, and clothe their bodies. Minnesota companies have been on the cutting edge of developing these new processes that may spur tremendous new opportunities for agricultural production. Our current hydrocarbon-based economy could very well be a brief aberration as we rediscover the carbohydrate economy. The potential benefits to the depressed farming sector, rural communities and the impaired rural environment of such a switch are significant and serve as a major impetus for this change.

There are several barriers slowing the development of the bioindustrial market, including:

- An "uneven playing field" between hydrocarbon and bio-based products, due to both unequal government support and the fact that market prices do not reflect the social and environmental costs of these products.
- Lack of research on specific bio-based products and their associated benefits and costs.
- The majority of public and private research dollars directed at the most dominant crops and processes, leaving relatively little funding for more promising alternative crops and cropping systems
- Inadequate state and federal incentive programs to support the bio-based sector in Minnesota and around the country.

At the same time, there are several drivers that provide momentum for rapid growth in the bioindustrial economy:

- The rising costs, uncertainty, and environmental concerns regarding the use and impacts of fossil fuels.
- The development and maturation of bio-based technologies and processes that allow higher performance conversion and production.
- The potential for this sector to provide new and stable markets and economic opportunities for farmers and rural communities.
- A growing recognition amongst policymakers, the industrial sector and the general public that bio-based initiatives are important and should be nurtured.

In order for the bioindustrial market to expand, it is critical that public policy plays an important role. Major recommendations for policymakers include:

- Evaluating the true costs and benefits of both hydrocarbon- and bio-based products
- Quantifying the impact that the bio-based sector will have on the economy, environment and rural communities
- Increased public investment in research on bio-based products and bioenergy
- Increased market access for the bio-based sector through preferred government procurement programs and portfolio standards
- A Minnesota incentive program that supports locally-controlled bio-based initiatives

If policymakers make the commitment to the bioindustrial marketplace, Minnesota is well positioned to reap huge rewards in the next few decades. Currently, Minnesota's ethanol industry already generates more than $1.3 billion in economic activity and 5,300 jobs. According to a study by a national research organization, adoption of a renewable energy standard (RES) of 20 percent by 2020 would create 5,020 new jobs and generate an additional $60 million in revenue and $80 million in gross state product for Minnesota's economy. Payments to farmers for wind tower leases and biomass production is estimated to total $383 million, with the state getting an additional $1.7 billion in new capital investment. [1] Without even including the other major, multi-billion dollar markets such as lubricants, chemicals and plastics of which bio-based products are rapidly increasing their share, it is abundantly clear that Minnesota has much to gain—or, if it does not act, to lose—from the emerging bioeconomy.

Both the U.S. and Minnesota policymakers have an important role to play in fostering the bio-based economy. Ethanol and wind energy have become state success stories only because of incentive payments, production tax credits, grant and loan programs and a host of other initiatives. The potential multiple benefits and opportunities that the development of the bio-based sector could provide warrant similar public investments and support. However, these programs need to be designed and managed in a manner that assures that Minnesota's bio-based sector benefits not only industry and consumers, but also achieves other societal goals such as revitalizing the farm economy and rural communities, and restoring the environment.

Introduction

A number of factors have converged to spur a growing excitement in bio-based energy and products. Rising fuel prices, increased uncertainty about stability in the Middle East, and our dependence on foreign energy sources have brought increased attention to alternative fuel and energy sources. Advances have been made in technology and processing that allow for the production of fuel, energy, plastics and other needed products and materials from agricultural crops and waste materials. Consumers and industry alike are increasingly aware of the negative ecological and health impacts of fossil fuel use and are increasing demand for energy and products that are more environmentally friendly. And farmers and rural communities are looking to bio-based industrial production as a way to bring new vitality, jobs and opportunity to depressed rural areas. The combination of these and other factors has caused an upsurge in research, investment and policies focused on the emerging bio-based sector. Whether it is bio-based fuel and energy production, building materials and health products made from fiber crops, or food production marketed on environmental and social attributes, new and high value markets for products derived from agricultural crops are emerging that can help lift rural economies, protect and enhance ecosystems, and provide income and resiliency for rural Midwestern communities.

A growing alliance of innovative manufacturers, farmers, university researchers, state and federal agencies, and nonprofit organizations recognize the potential for Minnesota in this emerging bio-based economy. Over the past two years, many of these parties have been meeting on a regular basis and have formed the Bioindustrial Development Partnership. The Partnership believes that this collaborative approach provides Minnesota the best opportunity to develop these markets in a manner that not only produces jobs and profits, but also benefits farmers, rural communities and the environment. Many of the case studies in this paper are from companies participating in the Partnership.

Capturing opportunities associated with the emerging bio-based sector will require both individual entrepreneurship and supportive state and federal policies. This paper identifies some of these new opportunities in Minnesota. It also provides information and insight into how rural Minnesota—and by extension, farmers and citizens everywhere—can revitalize their future by helping develop these new agricultural-based markets and products. Finally, recommendations are included to help assure that state and federal support for such market development provides the most benefit to Minnesota's economy, environment and citizens by linking the growth of this market with community revitalization, ecosystem protection and improved farm incomes.

The historic opportunity

The United States began as a land of farmers, foresters and trappers. Expansion of the original colonies was driven by the quest for land and opportunities for those who tilled the soil and harvested nature's bounty. In 1790, only five percent of the four million inhabitants of the United States lived in urban areas with 2,500 or more residents.[2] When Alexis de Tocqueville visited the United States in 1831, ten out of every 11 Americans lived on family farms.[3] America grew rich through its agricultural and natural resource production, which provided the capital and motive for expanding our infrastructure and boundaries, fed our growing population, and fueled our manufacturing. By the beginning of the 20th century, the role of agriculture as the foundation of our society, economy and industry was indisputable. From the energy provided by wood and agricultural oils and spirits, to the multiple products derived from fiber and food crops, agriculture fired, fueled, clothed and fed America and much of the world.

In the mid-19th century, however, hydrocarbons, or fossil fuels, emerged as a viable source of energy and materials production. First with coal and then in the 20th century with petroleum, the U.S. and the world began moving away from agricultural-based (carbohydrate) feedstocks for energy and materials production. By the middle of the 20th century research and development on carbohydrate energy virtually ceased.[4] Accompanying this shift was a dramatic change in agricultural production practices and technology. Until the introduction of tractors and large-scale production, a significant percentage of a farm's output had to be directed towards its own energy needs such as grain drying, heating buildings and feeding draft animals and human laborers. With tractors and machinery came a shift in production needs, inputs and fuel usage, as gasoline and diesel replaced oats and biomass. This conversion, which occurred both on the farm and throughout society, had many consequences for agriculture, society and the environment.

Agriculture's role in generating jobs and wealth significantly declined throughout the 20th century, resulting in the lowest number of farmers per capita in our nation's history.[5] At the century's end, the farm population stood at less than two percent of the total population, and even for those who remained in

Graph 1. The number of farms vs. average farm size

Source: Census of Agriculture: various years

farming, almost 90 percent of household income came from non-farm sources.[6] At the same time, average farm size increased significantly, as farmers needed to increase production—through both higher yields and additional acreage—to remain profitable. With plunging or stagnant prices, increasing costs for inputs and land, consolidation in agribusiness and reduced opportunities for added-value for local communities, farming in America increasingly became a low-return, high-risk venture that fewer and fewer people could afford to or were willing to undertake.

The impact of farming's decline on rural communities is clear, as the number of "viable" rural towns dependent upon agriculture and its associated industries continues to drop alongside farm numbers. Today, many of the poorest counties in the U.S. are rural counties.[7] These areas are losing not only residents, but also their economic and social foundations, as the many of the remaining farm operations either source their inputs and sell their products in larger regional centers or are too few in number to provide the support needed to maintain local community structures and businesses. In Minnesota, poverty rates in rural farm counties are 30 percent higher than in metropolitan counties, and rural counties' average per capita incomes are only 66 percent of those of urban counties.[8] With only a fifth of the job growth compared to metropolitan counties from 1990-2000, the results for rural Minnesota and America are aging and decreased populations, reduced job opportunities and living standards, and an increased sense of hopelessness.[9]

For the environment, the results of the shift from carbohydrates to hydrocarbons are even more traumatic. While burning carbohydrates certainly produced pollution, the increased utilization of petroleum-based products for fuel, energy and materials has resulted in significant increases in environmental damage.[10] In less than 150 years, enormous quantities of carbon, mercury, sulfur and other contaminants that had been stored in the earth for tens of thousands of years have been released into the atmosphere. From extraction to processing, utilization to disposal, the hydrocarbon system has impaired water and air quality, released numerous and significant quantities of toxins into the environment, degraded wildlife habitat and increased health and safety issues for citizens around the globe. The earth itself is being altered, as hydrocarbon combustion increases the concentration of carbon dioxide in the atmosphere, which is widely believed to contribute to global climate change. These social and environmental considerations, combined with both the mounting costs and risks associated with dependence on foreign fossil fuels and the increased availability of new technologies that can utilize plant-based materials more efficiently, serve as an impetus to rethink our energy future.

"I BELIEVE the Great Creator has put ores and oil on this earth to give us a breathing spell ... As we exhaust them, we must be prepared to fall back on our farms, which are God's true storehouse and can never be exhausted. For we can learn to synthesize materials for every human need from the things that grow."

—George Washington Carver (1864-1943)

Bio-based products and energy are anything but new. However, in recent years there has been a significant increase in bioindustrial production and processes. Whether it is ethanol derived from grain or plant matter, plastics made from corn, or building materials made from straw, opportunities and markets for bio-based products are growing. The reasons for this upsurge in research, development and production of bio-based products are varied, but include the following:

Technological innovations

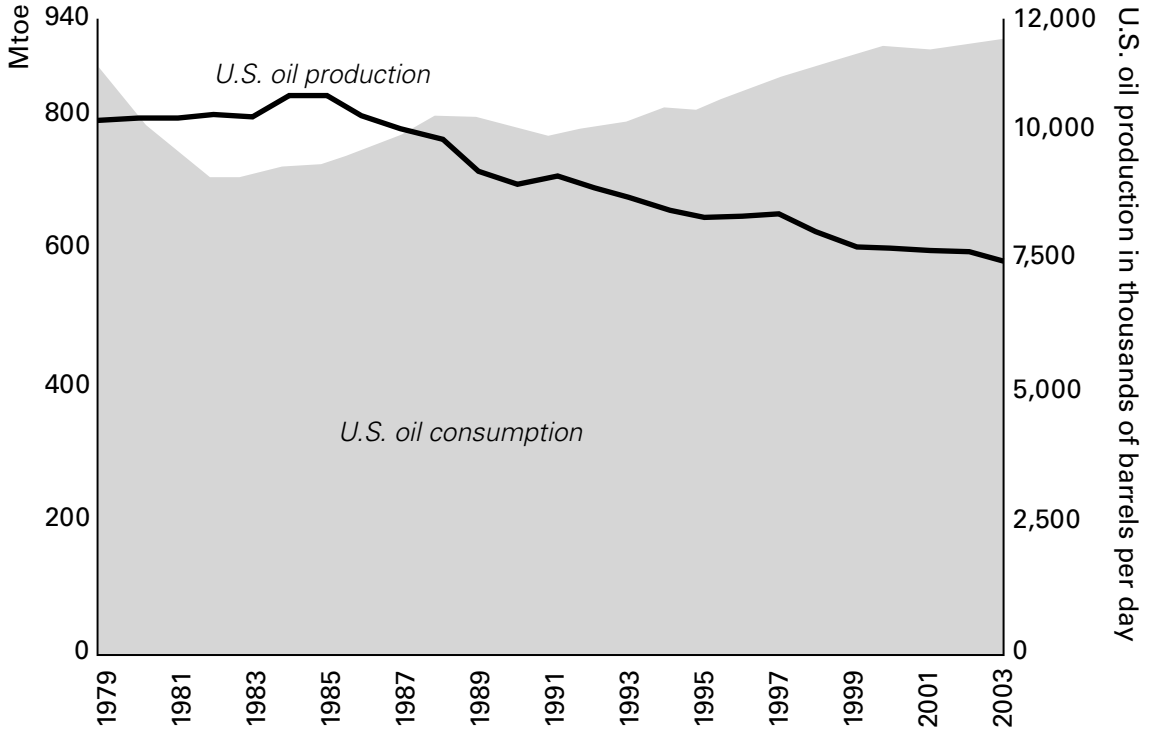
While it is true that bio-based production has existed for centuries, many traditional applications—especially for heat and energy production—are too inefficient or unable to meet modern production requirements. However, recent technological advances have helped to reduce energy and material losses and in the process have improved both efficiencies and profit potential of bioindustries. Advances in enzyme production, material processing and biorefining are also providing new or significantly improved bio-based products. For example, plastics are now being made from corn in a manner that meets quality needs of customers while still allowing for fully biodegradable materials. Construction materials that have desirable properties, including superior strength compared to traditional materials, are being produced from agriculturally produced fibers. New ways of extracting nutrients and "co-products" from corn and other grains and crops prior to ethanol conversion are increasing the value of the feedstock material and end products while reducing overall energy loss in the system. In these and many other cases, technological innovations have either helped to increase a product's value and/or efficiency, or opened entirely new markets for bio-based products.

Increasing scarcity of traditional energy sources

While there is much dispute about global fossil fuel stocks and reserves, it is undeniable that increasing demand and corresponding costs for finite resources such as petroleum are a leading driver for the expansion of bio-based industries. Many of these hydrocarbon sources have seen significant price increases in recent years. Among other factors, unrest in the Middle East and industrial growth in China and India are expected to keep demand high for existing and future supplies. On a price comparison, bio-based fuels have

generally not been competitive with hydrocarbons, but this is beginning to change, as fossil fuel costs rise and processing advances make ethanol and biodiesel more affordable. Interest and investment in biomass heating and energy production is growing as well, as advances in technology make these processes more affordable. When compared to the rising costs for natural gas and other fossil fuels, bio-based solutions are becoming much more attractive and affordable.

Graph 2. U.S. oil production vs. U.S. oil consumption, 1979-2003



Environmental concerns

The negative environmental effects of fossil-fuel use are a primary motivation for some pursuing cleaner, bio-based alternatives. The impacts of smog, carbon monoxide emissions and other hydrocarbon-related pollution on human and animal health, ecosystems, water and air quality, and our infrastructure are well documented. Fossil-fuel emissions are also the major source of anthropogenic greenhouse gases, which are contributing to global climate change. The effects of hydrocarbon use are beginning to mount, economically as well as environmentally. Mitigation is increasing in cost from both a health and an environmental standpoint. Awareness of the effects and costs of hydrocarbon use is a significant factor in the rise in interest and investment in bio-based alternatives.

Much of the environmental allure of bio-based energy and products is the potential benefit to the environment of large-scale production of perennial as opposed to annual crops. While corn, soybean and other annual crops can be produced in a sustainable manner, it is well documented that perennial crops such as switchgrass, willow and alfalfa are generally better at reducing erosion and nutrient runoff. Broad introduction of perennial biomass crops on marginal or sensitive land could help to significantly improve water quality. In this manner, bio-based feedstocks produced from a working landscape can not only offset current environmental degradation, but can actually contribute to its environmental enhancement while providing income for farmers and needed materials for industry.

Agricultural and rural revitalization

Consolidated markets, low prices and failed policies have contributed to a long-simmering crisis in rural areas. As farms have gotten bigger and more industrialized, small towns, family farm incomes and rural services and opportunities have declined. For the struggling rural sector, bioindustrial development offers an opportunity for revitalization. With agriculturally produced crops as feedstocks, farmers stand to gain new and potentially more profitable markets. The diversity of markets can also translate into diversity on the agricultural landscape, as the use of non-traditional commodities and farm products will allow farmers more choices in their crop rotations. Opportunity exists for rural towns as well, as transportation and processing limitations, as well as scale benefits, favor smaller-sized facilities located near the feedstocks. Processing, packaging and other value-added opportunities associated with the bio-based market can help bring new jobs, investment and income to struggling rural communities. The promise of such possibilities is why the bioindustrial sector is being looked at as a potential vehicle for promoting sustainable rural development and improved farm viability.

If policymakers make the commitment to the bioindustrial marketplace, Minnesota is well positioned to reap huge rewards in the next few decades. Currently, Minnesota's ethanol industry already generates more than $1.3 billion in economic activity and 5,300 jobs. According to a study by a national research organization, adoption of a renewable energy standard (RES) of 20 percent by 2020 would create 5,020 new jobs and generate an additional $60 million in revenue and $80 million in gross state product for Minnesota's economy. Payments to farmers for wind tower leases and biomass production is estimated to total $383 million, with the state getting an additional $1.7 billion in new capital investment. [11] Without even including other markets such as lubricants, chemicals and plastics—multi-billion dollar sectors which bio-based products are increasingly entering—it is abundantly clear that Minnesota has much to gain—or, if it does not act, to lose—from the emerging bioeconomy.

Minnesota case study #1

Faribault Mills

German immigrant and craftsman Carl H. Klemer founded Faribault Woolen Mills Company in 1865. Klemer believed from the beginning that his products would be unique in the marketplace if he controlled all components of the design and manufacturing process that transforms raw wool into woven blankets and other products. Thus began a Faribault tradition of dyeing, carding, spinning, weaving, napping, and finishing in a single location under rigid, uniform conditions using original blanket designs. It was a strategic move that eventually would lead the company to become the nation's foremost maker of wool blankets.

Faribault Woolen Mills grew and prospered during the early and mid-1900s, and its famous brand name became a symbol of high-quality and craftsmanship. Faribault was just one of 800 mills in the central U.S. but by the mid-1990s' it was the lone survivor in what was once a thriving north central wool mill industry, a testament to the quality and craftsmanship of its fine products. "To be the last mill operating in America, people said we must either be lucky or dumb," says Mike Harris, CEO of Faribault Mills. "However, I believe we survived and prospered due to our quality products, committed and skilled workforce, and our willingness to innovate."

Faribault Woolen Mill is now poised on the cutting edge of expansion and continued success for the new millennium. Faribault continues its position as an industry leader, introducing innovative new products, colors, and styles. Having acquired 'Beacon Blankets' (est. 1904), located in Westminster, South Carolina and traditionally recognized as the finest cotton blanket mill in America, Faribault Mills is the largest blanket manufacture in the United States today.

Besides providing a needed market for traditional agricultural products such as wool and cotton—two extremely depressed commodity sectors—Faribault Mills is also utilizing some cutting edge natural materials in its products. Natureworks (formerly Cargill Dow LLC) has developed a process to produce a Polylactic Acid (PLA) plastic from corn, which has most of the attributes of traditional petroleum-based plastics without many of the associated waste and energy concerns. PLA is fully compostable and its production utilizes much less energy than the equivalent petroleum-based plastic (PET) process. Used for food containers, candy wrappers, disposable dishware and product packaging, PLA can also be turned into a fiber, called Ingeo. Dennis Melchert, Director of Design and Corporate Development for Faribault Mills, spent countless hours experimenting with this new bio-based fiber to get it into an acceptable and dyeable yarn format that was suitable for weaving and finishing. Having succeeded in developing an in-house process for weaving Ingeo, Faribault Mills has introduced several new 100% Ingeo and wool and Ingeo blended blankets, each with unique and desirable properties.

"The state and federal government have long acknowledged the multiple benefits associated with bio-based production," says Harris. "However, recognition is not the same as support. To truly help bio-based businesses and the farmers and rural communities that depend upon them, governments need to translate this acknowledgement into functioning procurement standards and programs that give preference to products based on environment and social considerations as well as cost."

Information taken from personal communications with Faribault Mills management and from the Faribault Mills website. For more information, see faribaultmills.com.

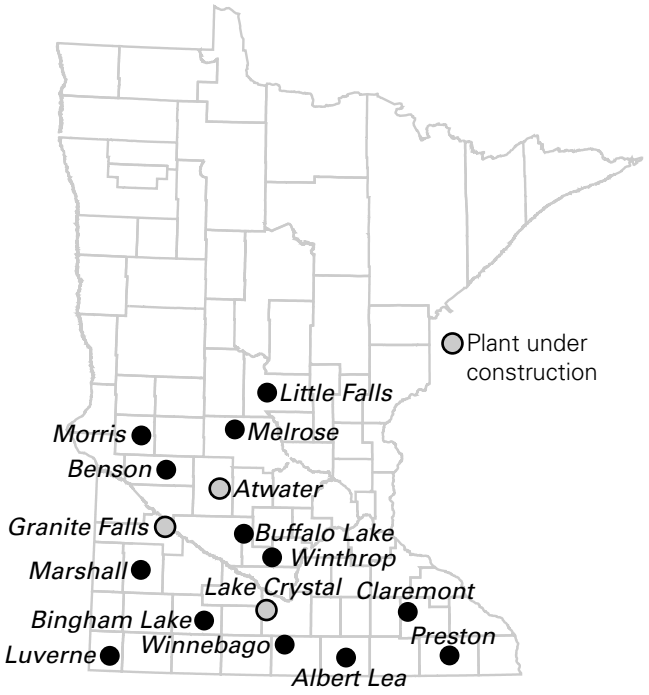
Bio-based sectors

While it is difficult to categorize all bio-based uses—especially considering that new products are being developed every day—the primary categories for production are energy (including fuel, electricity and heat production); bio-refining (whereby plant matter is processed to derive basic ingredients and nutrients); and bio-based materials and products (items made utilizing traditional or non-traditional plant materials).

Energy

Today, energy is the leading and most developed sector of bio-based production. Ethanol production is becoming increasingly efficient and competitive, especially with the negative environmental impacts of methyl tertiary butyl ether (MTBE)—the only other accepted oxygenating additive—becoming more recognized. Although generally used as an additive to gasoline, ethanol is increasingly being used as a primary fuel source, with the expansion of E85 (85 percent ethanol, 15 percent gasoline mixture) fuel production and stations and the increased availability of Flexible Fuel Vehicles (FFV).

Graph 3. Minnesota's ethanol production, 2005

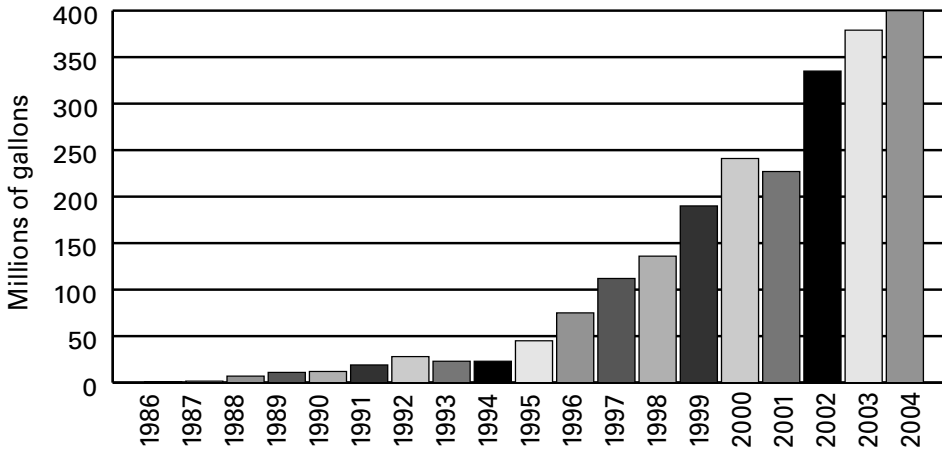


In 1986, Minnesota had a few small plants that produced about a million gallons of ethanol. Today there are 14 ethanol plants with an annual production capacity of over 360 million gallons—enough to replace 10 percent of the state's gasoline and export 100 million gallons. The state's corn milling industry grinds over 150 million bushels for use in ethanol production, doubling the value of 15 percent of the state's largest crop. For more information, see mda.state.mn.us/ethanol/about.htm. *Source: Teri Velner, Office of Minnesota Governor T. Pawlenty, "Energy Alternatives—Minnesota's Ethanol Program." Presentation given at National Governor's Association State Best Practices, April 29, 2004.*

Currently, ethanol is derived primarily from corn in the U.S., but in other countries sugar cane, sugar beets and sorghum are the main feedstocks, and other source materials such as milk whey are also being utilized. It is possible to make ethanol from any cellulose-based feedstock. Potential sources include agricultural wastes, grasses and woods, and even municipal waste. Although cellulosic materials are less expensive than corn, they are currently more costly to convert to ethanol because of the extensive processing required. Much effort and research is being put into reducing the costs of cellulose conversion. Successful introduction of cellulose-based ethanol production holds great promise for providing renewable fuel without compromising acreages and grain needed for food production.

Bio-based diesel fuels are also increasing market share and use. Derived from animal and vegetable fats and vegetable and grain oils, bio-diesel is less polluting than pe-

Graph 4. Minnesota ethanol production, 2004



troleum-based diesel fuel and less damaging to engines. The wide variety of useable feedstocks makes bio-diesel production possible in different crop growing areas. Production and utilization of bio-diesel is growing significantly, with production capacity up from 500,000 gallons in 1999 to an estimated 150 million gallons in 2004.[12] Soybean oil is the dominant feedstock for biodiesel production in the U.S., with rapeseed and sunflower oil more common in Europe. Other potential sources include beef tallow, chicken fat and used frying oil.

Table 1. Both ethanol and biodiesel have positive energy balances, while 17 percent of petroleum diesel's energy is spent obtaining it

Energy balance of biofuels[13]	
Fuel	Fossil energy balance
Ethanol	1.67
Biodiesel	3.2
Petroleum diesel	0.83

An important concern raised about ethanol and biodiesel production is the net energy balance of these products. When the ethanol industry first developed in the 1970s, most studies did find that ethanol required more inputs than what was produced. However, in the ensuing years, increased efficiencies in crop production and fuel processing have resulted in positive energy balances for both ethanol and biodiesel.

Minnesota has been a leader in ethanol and biodiesel production. A combination of an oxygenated fuel mandate and a 20-cent per gallon ethanol producer incentive has resulted in Minnesota producing 13 percent of the nation's ethanol.[13] In 2002, the state legislature passed a biodiesel mandate, requiring all diesel fuel sold in the state to contain at least two percent biodiesel by June 2005. To meet the coming need for biodiesel, the Minnesota Soybean Processors are finishing construction of a 30 million gallon biodiesel refinery at their Brewster processing plant.[14]

Electricity, heat and gas generated from the combustion or processing of biomass is another growing bio-based energy sector. With about 9,733 megawatts (MW) in 2002 of installed capacity, biomass is the single largest source of non-hydro renewable electricity.[15] Sixty percent of this biomass is derived from forestry and agricultural products. Wood and wood wastes, and agricultural crops and residues are the primary biomass feedstocks for combustion. Whether burned exclusively or co-fired with coal, biomass efficiency and usage is increasing as a way to reduce waste streams and emissions, add value to agricultural products and reduce use of fossil fuels.

Table 2. Minnesota biomass facilities

Location	Owner	Fuel type	Plant Name	Capacity (Kw)
Anoka	Power Recyclers Inc.	Other biogas (excludes landfill gas)	Anoka Landfill	5,000.0
Grand Rapids	Blandin Paper Co.	Timber residues (milling and logging residues)	Blandin Paper	31,500.0
International Falls	Boise Cascade Corp.	Timber residues (milling and logging residues)	Boise Cascade	29,300.0
Burnsville	Neo Corp.	Other biogas (excludes landfill gas)	Burnsville Sanitary Landfill (Eks Landfill)	4,200.0
Sartell	Champion Paper	Timber residues (milling and logging residues)	Champion Paper	24,000.0
Cloquet	Potlatch Corporation	Timber residues (milling and logging residues)	Cloquet (Wood Project)	61,400.0
Elk River	Great River Energy	Municipal solid waste (incl industrial, medical)	Elk River Station	38,000.0
Eden Prairie	Neo Corp.	Other biogas (excludes landfill gas)	Flying Cloud (Woodlake Sanitary Services)	4,800.0
Minneapolis	Ogden Corp.	Municipal solid waste (incl industrial, medical)	Hennepin County Energy Resource Facility	39,600.0
Duluth	Minnesota Power	Timber residues (milling and logging residues)	Hibbard, M.l.	7,050.0
Rochester	Olmstead County Public Works	Municipal solid waste (incl industrial, medical)	Olmstead County W-t-e- Facility	4,200.0
Invergrove Heights	Browning-ferris Industries	Other biogas (excludes landfill gas)	Pine Bend Landfill	12,000.0
Bemidji	Potlatch Corporation	Timber residues (milling and logging residues)	Potlatch Corp Pulp & Paper	12,500.0
Newport	Northern States Power Co	Municipal solid waste (incl industrial, medical)	Ramsey/wash-ington Resource Recovery Facility	22,000.0
Red Wing	Northern States Power Co	Municipal solid waste (incl industrial, medical)	Red Wing	22,770.0
St. Paul	St. Paul Cogeneration	Timber residues (milling and logging residues)	St. Paul Cogenera-tion Project	25,000.0
Mankato	Northern States Power Co	Municipal solid waste (incl industrial, medical)	Willmarth	24,750.0

Source: http://www.eere.energy.gov/state_energy/opfacbytech.cfm?state=MN

Biomass can also generate gases that can be used for energy production. Both landfills and livestock waste handling facilities produce biogas that is high in methane. This methane can be captured and used for energy. Biomass gasification uses heat to convert solid biomass into a biosynthesis gas, primarily a mixture of carbon monoxide and hydrogen. Once the gas is cleaned of tars it can be used to make electricity, alcohols and acids. Biogas can be burned (or co-fired) in a boiler to produce steam for electricity generation. It can also fuel gas turbines or combined-cycle generation systems. In a combined-cycle system, pressurized gas

first turns a gas turbine to generate electricity. Then, the waste gas from the gas turbine is burned to make steam for additional power production. Biosynthesis gas in advanced turbines or in fuel cells can produce electricity at more than twice the efficiency of today's combustion engines.[16] As a result of new technologies, the pulp and paper industry—which produces most of the energy it needs from burning its waste stream—could become energy self-sufficient and could even export 30,000 megawatts of electricity by 2030.[17] Finally, as mentioned earlier, biomass is being looked at as a potential source of ethanol and other liquid fuels.

Biomass energy production in Minnesota has been assisted by a biomass requirement on Xcel Energy. The company, in exchange for increased nuclear waste storage, was mandated by the Minnesota legislature to build or contract out 110 megawatts of closed loop biomass. In addition, Xcel Energy's Renewable Development Fund provided 19 projects with nearly $16 million in 2001. Minnesota also has a renewable energy objective, which requires electric utilities to make a good faith effort to generate or procure a percentage of their electricity from eligible renewable energy technologies. Wind is the most advanced of Minnesota's renewable energy technologies, but these initiatives have also fostered the biomass to electricity market.

The Union of Concerned Scientists has estimated that Minnesota has the technical potential to generate more than 13 times its current electricity needs from renewable sources

The Minnesota ethanol Story

Over the past two decades, Minnesota has taken a series of measures that have dramatically increased the production and consumption of ethanol within the state. Ethanol development has been pursued with a focus on satisfying domestic demand with domestic production from farmer-owned cooperatives, as opposed to developing an industry focused primarily on export. Goals of the ethanol program include:

- To build a new market for corn, the state's largest crop
- To develop corn processing/ethanol production facilities in Minnesota
- To increase the number of New Generation Farmer Coops (NGCs), a business model designed to provide farmer members greater direct cash return for their crops
- To replace 10 percent of imported petroleum used for gasoline in the state (over $100 million annual savings)
- To help the Twin Cities metropolitan area to meet U.S. EPA standards for carbon monoxide

The main components of the program are:

- Oxygenated fuel statute that requires state-wide oxy-fuel (ethanol blend) use
- A 20 cent per gallon ethanol producer incentive provides payment for ethanol produced

Results to date:

- 140 million bu. of corn (14 percent of Minnesota crop) is made into ethanol, livestock feed and other products
- Minnesota's 14 plants can produce over 400 million gallons of ethanol/year
- Twelve of Minnesota's 14 ethanol plants were originally organized as NGCs
- 10 percent of gasoline sold in Minnesota is being replaced by ethanol each year
- The Twin Cities Area met EPA's carbon monoxide standard and has achieved "attainment" status. The continued use of ethanol was required to keep emissions low

Changes proposed in 2005 by Minnesota Gov. Pawlenty:

- Require all gas sold in Minnesota to have 20 percent ethanol by 2010
- Require the state government reduce its on-road fleet's use of gasoline 25 percent by 2010, and 50% by 2015 through increased use of E-85 and hybrid technology

Minnesota case study #2

Koda Power

The Shakopee Mdewakanton Sioux Community and Rahr Malting Company, a 157-year-old family business, are joining together to form Koda Power. With a June 2006 completion date, Koda Power will generate 10 to 15 megawatts of baseload electricity and 125 million Btus per hour of process heat. The plant will utilize the waste grains from Rahr's malting process and other biomass byproducts as well as biomass purchased from local farmers. The reliable, dispatchable electricity produced by Koda Power's proposed biomass-to-energy project will be enough to power 4,000– 6,000 homes - from an environmentally friendly, renewable resource. The heat produced will replace all of the natural gas heat currently needed for Rahr's malting processes.

This project will significantly reduce natural gas demand, replacing enough natural gas to heat 11,000 homes. "As an agriculturally based company, we believe that producing energy from biomass is the right thing to do from an economic, environmental and social perspective," say Paul Kramer, Vice President of Rahr Malting. "Biomass compares very well if all costs are included, but unfortunately right now biomass is not on the same regulatory `playing field' as traditional energy sources such as coal and nuclear power."

The project will create numerous skilled jobs, giving Koda Power an expected annual payroll of over $750,000. To fuel its boilers, Koda Power will require up to 160,000 tons of biomass. This will annually pump $4.2 million into the local agricultural economy, and the long-term effects of this project will annually cycle over $15 million through the Minnesota economy. By providing year-round, dispatchable power, Koda Power complements other more intermittent power sources such as wind and seasonally variable sources such as hydroelectric and natural gas. Located near an electrical substation and major power lines, this project can add 10 megawatts of renewable power without requiring expensive transmission line construction and upgrades. "The state and regional utilities need to recognize the multiple social and environmental benefits of biomass energy production and modify outdated regulations and rules to help promote these projects," says Pat Mulloy, environmental consultant to Koda Power.

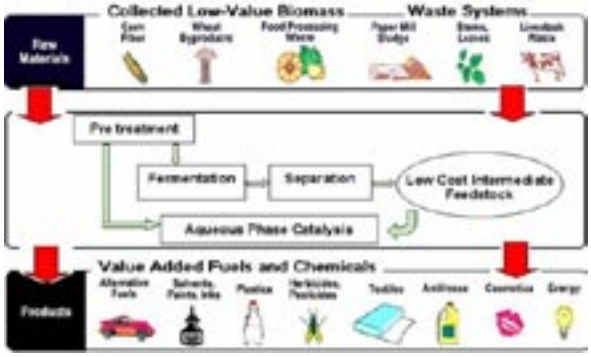
The development of a sustainable biofuels program will provide wildlife habitat, slow soil erosion and reduce surface and groundwater pollution. The project is located in the Minnesota River Basin - Minnesota's most polluted river. Perennial energy crops such as switchgrass can improve water quality by providing a continuous soil cover that stabilizes the soil, decreases nutrient transport and protects the soil from erosion. "Biomass production can improve farm incomes, help to clean up the rural environment and reduce waste streams going to our landfills," continues Mulloy, "but to succeed there needs to be incentives in place to make it possible and profitable for farmers and companies to pursue such projects."

Information taken from Koda Power documents and personal communication with Rahr Malting and Koda Power staff.

Biorefining

When one hears the word "refining," one generally thinks of the petroleum industry. In this process, crude oil hydrocarbons are refined into various useful products, including gasoline, kerosene, lubricating oil, fuel oil and petroleum gas. The same process can also be used for crops and other carbohydrates. Biorefining is emerging as a way to increase efficiency and profitability of bio-based processing by separating as many useable, valuable products from grains, agricultural crops and residues as possible. In the example of corn processing, products such as corn oil, concentrated protein, brewers yeast, corn gluten meal and high value sugars can all be extracted prior to ethanol production. For plant matter, breaking it down into its respective components (i.e. cellulose, hemicellulose, and lignin), can improve ease of processing and increase the amount and efficiency of product derivations. Whether this is done through the use of enzymes or other processes, the increased capture and separation ability of biorefineries holds real promise for increasing the value and number of products that can be derived from agricultural materials.

Graph 5. Biorefining system



Source: http://www.pnl.gov/biobased/pdo.stm

The significance for farmers and businesses is clear. The combined value of the potential corn products that can be derived through biorefining processes is estimated to be many times the value of ethanol and dried distillers grains, the current saleable product of ethanol plants. While many biorefining designs will require entirely new plants and systems, the capacity of some of the biorefining technology to be "retrofitted" into existing ethanol plants increases the availability and decreases overall investment required. By producing higher value products through a more efficient and potentially cost-effective process, biorefining has generated interest among not only ethanol plants and farmers, but also food, cosmetic, nutritional and energy companies, as well as state and local governments.

Bio-based materials and products

This is a very broad category, encompassing construction and composite materials, absorbents, cleaning chemicals, lubricants, oils, waxes, plastics, polymers, solvents, inks, dyes and many other related products. Nature has always been a source for many of the materials we use every day. From wood products used for construction and manufacturing to plant materials used in cosmetics, bio-based products are nothing new for

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"From a $2.00 bushel of corn we can make a combination of fuels, industrial products, chemicals and feeds with a total wholesale value of more than $8.00."

—From "Fostering the Bioeconomic Revolution in Bio-based Products and Energy"

Minnesota case study #3

Biorefining, Incorporated

Biorefining, Inc., based in Golden Valley, Minnesota, was incorporated in January of 2000. The vision of this cutting edge firm is "to develop, commercialize and license proprietary technologies capable of economically converting plant material into value-added products, used primarily for pharmaceutical, nutraceutical, and functional food applications, in addition to food and feed grade products." Biorefining's technologies maximize the number and value of co-products contained in a single raw material, fractioning the biomass in several subsequent levels of processing. According to Doug Van Thorre, Biorefining's President and Chief Technical Officer, "Right now, farmers and most bio-based companies are not getting as much value out of their production as they could. Farmers are stuck producing one or two crops, which are then processed at a minimal return. Instead, farms need to be looked at for what they really are – 'big oil wells' that can produce multiple high value crops and products."

The company currently maintains three technologies ready for commercialization: the Biomilling™ Process, the Bio-Extraction Process and the Bio-Conversion Process.

▶ The Biomilling Process encompasses the most basic fractionations of the raw material. Through a more efficient first or gross fractionation of the corn kernel into its component parts (corn germ, pericarp, and starch), the Biomilling Process replaces the front-end "dry-grind" process currently being used in most ethanol facilities. An ethanol producer utilizing the Biomilling front-end would provide a virtually starch-only feedstock to the fermentor for conversion to ethanol, resulting in reduced fermentor residence times, more efficient starch to ethanol conversion, elimination of most VOC's, and an increased number and value of marketable co-products.

▶ The Bio-Extraction Process economically and efficiently processes virtually any residual plant material into value-added components, mainly carbohydrates or specialty sugars (up to 30 products from one raw material source). Specialty sugars are currently used as starting materials and ingredients for dietary supplements, nutritionally enhanced foods, and the most cutting-edge pharmaceutical applications. The Bio-Extraction Process uses minimal water, is extremely environmentally friendly, and is ten times faster and ten times less expensive compared to wet chemistry methods currently used to extract these specialty sugars.

▶ Biorefining, Inc.'s third level of processing, the Bio-Conversion Process, focuses on the finest processing of bio-based products, either from the Bio-Extraction Process or obtained elsewhere, into the rarest and most valuable components. This technology further processes specialty sugars, producing very high-end/small volume specialty carbohydrates, which are currently being investigated by drug development companies for use as starting materials for HIV, Hepatitis B, and cancer drug formulations.

The Company's first commercial application involves their Bio-Extraction Process. This process will be used in a $22 million joint-ventured production facility between Biorefining, Inc. and Ace-Technologies, LLC, expected to begin production of specialty sugars in late 2005. Ace-Biorefining, LLC, the world's first "biorefinery", will be located next to the Ace Ethanol production plant in Stanley, WI. Groundbreaking for the biorefinery took place on October 24, 2003. Biorefining, Inc. also intends to license their first level of processing, the Biomilling Process, to ethanol facilities. "Our hope," according to Van Thorre, "is to help farmers and society by promoting efficient use of a variety of farm crops to produce high quality food, fiber and energy products."

Information taken from personal communication with Biorefining, Inc. employees and Biorefining Inc. website. For more information, see: http://www.biorefining.com

these industries. What is different is the variety of plants and applications that are now being utilized. For example, whereas wood was previously considered the only natural construction material, now wheat straw and other agricultural fibers and plant products are considered viable feedstocks. This diversification of feedstocks is also apparent in the production of bio-based inks, solvents, lubricants, detergents and paper.[18]

There are many "new" bio-based materials that are being produced as a result of technological advances. Bio-based polymers, plastics, ethylene, acetic acid and enzymes are entering markets or are currently under development. These products are creating significant interest in the marketplace, as many are similar or even superior when compared to the traditional product qualities and production costs. Considerations such as biodegradability, product life cycle energy and resource use, reduced toxicity and overall environmental impacts—all of which are attractive from both a materials and promotional perspective—are helping bio-based products to increase market share, investment and purchasing.

Bio-based products and uses

- Absorbents, adsorbents and activated carbon
- Cleaning chemicals, surfactants, soaps and detergents
- Construction and composite materials
- Fibers, bonded fabrics, carpets and textiles
- Foods, beverages & nutrients
- Fuels & fuel additives
- Gases & vapor technology
- Inks, dyes & pigments
- Landscaping materials
- Lubricants & rust inhibitors
- Oils, waxes, binders, & functional fluids
- Packaging
- Paints, coatings & adhesives
- Paper & paper products
- Personal health, hygiene & cosmetic products
- Pharmacology & nutraceuticals
- Plastics, polymers & films
- Soil amenders, fertilizers & ag chemicals
- Soil and water remediation
- Solvents & co-solvents
- Specialty chemicals, enzymes, fatty & acetic acids
- Water & wastewater treatment

Source: the New Uses Website (http://www.bio-based.com/)

While initially many companies were resistant to bio-based alternatives—whether due to price, quality or supply concerns—these products are increasing their market share at a dramatic rate as these concerns are alleviated. Bio-based products captured roughly $2 billion in the chemical market in 1999 and some analysts are projecting an increase to $160 billion by 2010.[19] Bio-plastics sales are projected to reach 8 billion pounds a year by 2020—a little over ten percent of the current U.S. plastics market.[20] Other markets are ripe for increased bio-based product introduction as well. According to the Office of the Chief Economist at the U.S. Department Agriculture in 2000, "There is a $5.1 billion market in lubricant sales, $14.6 billion in composites, $43 billion in paint, and $77 billion in plastics."[21] Just gaining five to ten percent of each of these markets—a conservative estimate—the impact on farm and rural economies could be profound.

Minnesota's most well known new bio-based company is Natureworks, initially a joint venture between Cargill Incorporated and Dow Chemical, which was bought out by Cargill in 2004. The company opened a plant in Blair, Nebraska in 2001 that derives polyactic acid (PLA) from corn. PLA is an extremely versatile plastic that uses 20 percent to 50 percent less fossil fuel than conventional plastics. It is currently used as a substitute for polyester and as a packaging material. The potential market for these products is enormous.

Minnesota case study #4

Environ Biocomposites, LLC

In June 1992, a company was started in Mankato, Minnesota to develop and commercialize a new technology for the construction, furniture, cabinet and design industries. Initially called Phenix Biocomposites, this company utilized a unique process to produce high quality biocomposite boards from agricultural materials (wheat straw, soy and sunflower seed shells) and recycled newspapers. The system utilized by Phenix produced panel products in a similar manner to those manufactured by the wood-based panel industry, but with a fraction of the energy inputs and much lower emissions. Through the use of environmentally sound manufacturing techniques, Phenix was able to produce these products in a way that does not release VOCs (Volatile Organic Compounds) into the environment by utilizing materials that do not contain formaldehyde.

Over the last few years, the company has gone through some management and structural changes. The resulting company, Environ BiocompositesTM, is picking up where Phenix left off. Their plant is a world-class manufacturing facility capable of producing over 40 million feet of composite material annually. By utilizing renewable, sustainable and recycled resources, their products deliver better value to the marketplace and also represent environmentally sound alternatives to traditional wood-based products. Their commitment to the environment can be seen not only in the materials they produce but also in their day-to-day operations. The firm's research and development lab has also worked with a number of companies and local governments looking for ways to convert current waste streams into desirable products. In particular, they are working with key customers to explore product-recycling possibilities, as research has shown that the majority of the panels may be reused in current or new product lines.

By utilizing agricultural waste streams and products, Environ Biocomposites is providing a needed market for farmers to gain additional value out of their production. According to Krista McCarthy of Environ Customer Service, "Over the past twelve months we've seen a dramatic increase in demand for bio-based alternatives from architects, designers and furniture manufacturers. Their clients are requesting alternative materials that meet requirements for environmentally driven public and private sector programs."

The success and emergence of Environ has been limited in part due to supply questions and certification issues associated with entering traditional markets. "One hurdle is the need to obtain product certification in an industry geared toward wood products," says Environ CEO Derek Fisher. "Key players in the market will need to develop and accept evaluation methodologies and standards that are appropriate for bio-based products as well." However, such obstacles are not seen as surmountable, given the appropriate education process happens among customers and consumers.

Information taken from personal communications with Environ staff and the Environ website. For further information, please see: http://www.environ-biocomposites.com/biorefining.com

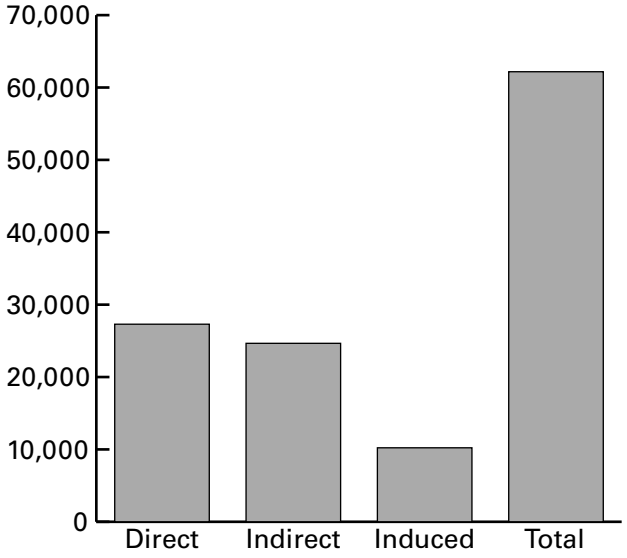
Minnesota and bio-based industry: A natural and traditional alliance

For Minnesota—a state with a favorable climate, significant soil and water resources, a strong agricultural and transportation infrastructure and skilled and educated workforce—the opportunities associated with the new bio-based industry are clear. A brief look at these resources will show how Minnesota's assets give it a significant advantage in this sector and how, if developed and supported, the emerging bio-based economy can be advanced with appropriate leadership to the benefit of the state and its residents.

Agriculture and forestry

Minnesota has retained more of a rural character than much of the U.S., with 29 percent of the population remaining in the countryside.[22] The broad agriculture sector, including production, processing and manufacturing, is the primary land use in the state and the second largest sector of Minnesota's economy. An estimated 80,865 farms cover 56 percent of the state's total land area, with that percentage much higher in southern Minnesota.[23] These farms produce a prodigious amount of crops, livestock and dairy products, with total revenues of $7.9 billion in 2001, ranking it 6th in the nation.[24] When processing and manufacturing of agricultural products is factored in, the total economic impact of the agriculture sector in 2002 was $62 billion supporting 495,000 jobs statewide.[25]

Graph 6. Minnesota 2002 agricultural economic impact, in millions of dollars



Source: "Minnesota Agriculture: The Foundation of Minnesota's Economy," Minn. Dept. of Agriculture, 2003.

Forestry is also significant in Minnesota from both a land use and an economic perspective. Approximately 16 million acres of forested land cover 32 percent of the state.[26] While over half of this land is publicly owned, there are over 100,000 private forest owners who together account for around 40 percent of the total acreage. Forest-based industries employ nearly 61,000 Minnesotans and contribute $7.7 billion annually to the state economy, making them a vital part of our natural resource based economy.[27]

Workforce

Minnesota's effective, skilled and committed workforce is another major asset for the development of the bio-based sector in the state. Overall, Minnesota leads the nation in the proportion of adults actively in the workforce.[28] A high level of education is also advantageous for the expansion of bio-based industries, as the ability to master new skills and technologies is a requisite for this sector. Minnesota has long been known

for its quality education system, and the results are born out in statistics: 88 percent of all Minnesotans in 2000 above the age of 25 had finished high school and 59 percent have attended college.[29]

Infrastructure and business climate

Minnesota also has a well-developed infrastructure, which is essential for bio-based production, considering the transportation, storage and processing needs associated with this industry. Minnesota has the fifth largest highway system in the country and is positioned on two major commercial waterways, the Great Lakes/St. Lawrence Seaway system and the Mississippi River. There are also 26 rail carriers in the state, which operate on 4,544 miles of track (MN Atlas).[30] Finally, as a traditional agricultural and processing region, Minnesota is home to many agricultural and bio-based companies and the state has a reputation for developing new agricultural markets and products.[31] Working together, the state, farm groups, and local agribusinesses developed innovative incentive programs that helped to birth first the ethanol and now the soy diesel industries, and the state is looked to as a leader in developing bio-based markets and sectors.

Minnesota crop production

Minnesota's soils and climate are ideal for a number of crops, many of which have current or potential bio-based applications. Corn and soybeans, the two dominant crops, already have applications in renewable fuels, oils, lubricants, and other industrial processes. Alfalfa stems, wheat straw and corn stover have also been used for energy and construction material. As Minnesota produces 15 million tons of crop residue each year, there is significant potential to utilize some of this material without detrimental impacts to soil quality. Additionally, two crops that produce large volumes of biomass, hybrid poplars and switchgrass, could also evolve into a larger part of the Minnesota agricultural economy.

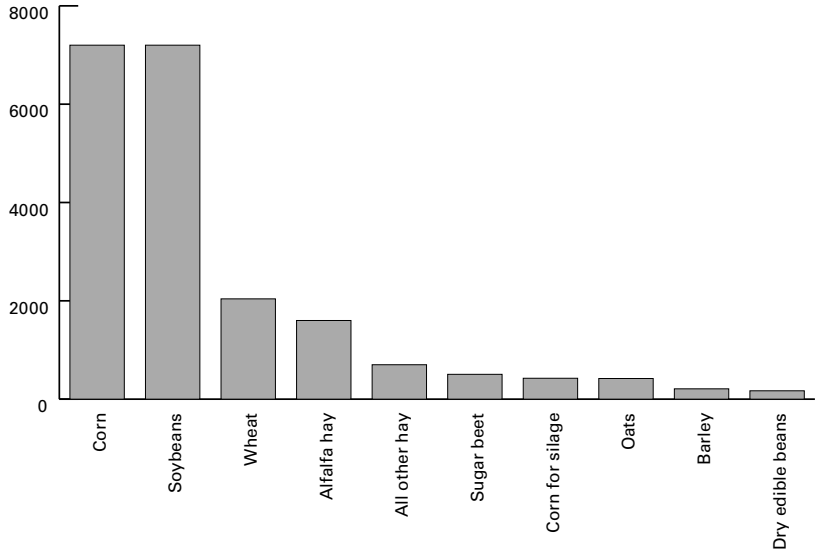
Biomass can be derived from agricultural residues, forestry residues, or energy crops. Currently, the least cost sources of biomass that have been identified are urban wood waste and mill residues, which can often be obtained for less than $2.00 per million Btu. Agricultural residues become viable at $2.00 per mmbtu, while energy crops (crops produced primarily for use as feedstocks in energy generation) and forestry residues are viable at $2.30 per mmbtu.[32] Biomass is competitive with coal ($1.50-2.00 per mmbtu) and natural gas ($3-4.00 per mmbtu).[33]

This demonstrates the importance of obtaining multiple revenue streams from crops. Biomass for energy is a relatively low value use of a crop, and the more that can be utilized by higher value uses such as feed or bio-refining, the better. There may very well be opportunities to obtain economic benefits for the environmental services that different production practices could also provide. Switchgrass, for example, is a perennial that provides significantly better soil protection and wildlife habitat than row crops like corn and soybeans.

Another benefit that biomass production can provide is increased diversification of Minnesota's agriculture. As biomass for energy becomes increasingly cost competitive with other energy sources, some land traditionally planted in grains and oilseeds will shift to other crops, particularly in regions outside of the Corn Belt. A 1998 study on energy crop production predicted that switchgrass could become a significant crop in the northeast and north central regions of the state. This shift would benefit all Minnesota farmers, as prices of grains and oilseeds would rise with the reduced supply.[34]

Minnesota-based companies and organizations have taken advantage of Minnesota's crop diversity for grain processing (Cargill, Pillsbury), cosmetics (Aveda), construction materials (Environ Biocomposites), traditional and new technology blankets (Faribault Mills) and biomass energy production (Rahr Malting).

Graph 7. Minnesota crop acreage, 2002, in thousands of acres



Source: National Agricultural Statistics Service, http://www.nass.usda.gov/mn/agstat03/p023028.pdf

Barriers and drivers:

Recommendations for moving the bio-based sector forward nationally and in Minnesota

The national research council estimates that the potential market share for bio-based products is enormous.

Table 3. Targets for a national bio-based industry

Bio-based product	Bio-based production levels (percent derived from bio-based feedstocks)		
	Current level	Future target: intermediate (2020)	Future target: ultimate (2090)
Liquid fuel	1 –2%	10%	Up to 50%
Organic chemicals	10%	25%	90+%
Materials	90%	95%	99%

Source: "Bio-based Industrial Products: Priorities for Research and Commercialization," NRC 2000

However, these targets cannot be reached without a collaborative effort to address development barriers and take advantage of opportunities. Some of these barriers include:

- An "uneven playing field" between hydrocarbon and bio-based products, due to both unequal government support and the fact that market prices do not reflect the social and environmental costs of these products.
- Lack of research on specific bio-based products and their associated benefits and costs.
- The majority of public and private research dollars directed at the most dominant crops and processes, leaving relatively little funding for more promising alternative crops or less intensive processes.
- Inadequate state and Federal incentive programs to support the bio-based sector in Minnesota and around the country.

There are, however, several drivers that are creating a tremendous opportunity in coming years, including:

- The rising costs, uncertainty, and environmental concerns regarding the burning of fossil fuels.
- The difficult economic situation for farmers growing traditional crops, thereby increasing the willingness to participate in bio-based initiatives.
- A growing recognition amongst policymakers and the general public that bio-based initiatives are important and should be nurtured.
- The large acreage of Minnesota cropland that has been enrolled in the Conservation Reserve

Program and other set aside programs, and will be leaving these programs in coming years. Farmers are more willing to experiment with alternative crops on land that has been set aside for several years.

We can address the barriers and take advantage of the drivers through initiatives that foster further research and market development. Priorities should include the following:

Understanding the true costs and benefits of both hydrocarbon- and bio-based products. If one takes into account all of the subsidies—hidden and otherwise—of the fossil fuel industry, it is readily apparent that petroleum is much more expensive than prices reflect. Including the direct subsidies provided by the government, the costs associated with hydrocarbon pollution remediation, health care concerns from smog, and transportation expenses, the support provided by U.S. taxpayers is quite significant. Compared to the "true cost" of oil, which is estimated to be somewhere between $5.60-$15.14/gallon, bio-based energy is very competitive.[35]

One particularly promising method that is helping to both clarify these real costs and quantify the associated benefits of bio-based alternatives is a new tool that looks at the full impacts of a product from its creation through disposal. A "Life Cycle Assessment," (LCA) looks at the amount of energy used throughout a product's full life and what impact that product has on the environment, providing a better understanding of the actual costs of a particular product. While bio-based products can also be quite energy intensive, in general they do much better in an LCA compared to hydrocarbon alternatives.

Quantifying the impact that bio-based products have on the economy, environment and rural communities. While it is generally agreed that bio-based production can provide useful products that improve environmental quality and rural

Minnesota case study #5

Aveda Corporation

Horst M. Rechelbacher, an active environmentalist, innovative business leader, author and artist, started the Aveda Corporation in 1978. Based in Blaine, Minnesota, his company was different from other cosmetic companies from the start, as it focused exclusively on plant-based materials for its products. The unique business approach of Aveda is reflected in its mission statement: "to care for the world we live in, from the products we make to the ways in which we give back to society. At Aveda, we strive to set an example for environmental leadership and responsibility, not just in the world of beauty, but around the world." Aveda has proven that it is possible to be financially successful while promoting a sustainable business model.

And Aveda isn't stopping there. Purchased by Estee Lauder in 1997, Aveda continues to broaden its commitment to sustainability. Aveda is constantly striving to improve its products, which includes introducing sustainability standards for production of its base materials and requiring, wherever possible, that all feedstocks are certified organic.

Aveda researchers and scientists are also working with University researchers, farmers and non-profit organizations in Minnesota and elsewhere to identify and source crops and materials that can be raised locally by farmers. Considering the variety and amount of plant materials that Aveda utilizes, this commitment to local production is a significant opportunity to broaden markets for local farmers and rural communities and increase biodiversity and sustainable production on the rural landscape.

Information taken from Aveda website and discussions with Aveda staff.

For more information about Aveda, see: http://www.aveda.com/

vitality, supporting data are still minimal. There is a strong need for further research on specific bio-based product characteristics, their associated environmental and social benefits, and economic issues related to the establishment and operation of these production systems. Such considerations are needed, as broad success in bio-energy introduction could lead to some unintended environmental problems associated with large monocultures on the landscape.

The ownership and scale of this emerging industry need to be considered when conducting research and developing programs. Minnesota's ethanol industry has provided direct support to growers and benefited local communities because the state's incentive program gave preference to smaller, farmer-owned systems. Similar considerations of community and regional impacts need to be included in the development of any new bio-based production incentive programs.

Increased public investment in research on bio-based products and bioenergy. The U.S. invested almost a quarter of a billion dollars in development of bio-based products and bioenergy in fiscal year 2001, targeting energy security, climate change, rural development and environmental improvement goals, Compared to industry investments, however, the public interest research is not sufficient to ensure adequate consideration of environmental and community issues.[36]

Under the Agricultural Biomass R&D Act of 2000, Federal agencies are required to work together to fund research and foster emerging bio-based products and the bioenergy industry. Much of this funding is used in cost-sharing (matching) arrangements with industry partners. For example, a document, Plant/Crop-based Renewable Resources 2020, was developed jointly by industry and the government to guide efforts in this sector.[37] This is the type of collaborative research that has the best chance of moving the industry forward.

Increased market access for the bio-based sector. Just as in the development of the Internet, hydrogen fuel cells and many other innovative technologies, public policy and investment plays a crucial role in getting industries established. Ethanol, when first introduced, was more expensive to produce than gasoline, and as a result its commercialization was limited. However, state and federal programs have given the industry the market access, pricing and investment needed to become more efficient and profitable.[38]

An important policy initiative was taken in the 2002 Farm Bill, where the Federal Bio-based Products Preferred Procurement Program will require federal agencies to greatly increase their use of bio-based industrial products. The procurement is mandated whenever their cost is not substantially higher than fossil fuel-based alternatives, when bio-based industrial products are available in needed quantities, and when bio-based industrial products meet the performance requirements of the federal user.[39]

Perhaps the most important policy option that could boost biomass and all renewable energies is the adoption of a renewable energy standard (RES). This would require an increasing percentage of electricity supplied by utilities to be derived from renewable sources. Two renewable energy standards that have been proposed are ten percent by 2010 and 20 percent by 2020. A ten percent RES would likely have minimal impact on the biomass industry, as most of the standard could be met by the well established and lower cost wind industry. A 20 percent RES, however, would provide an enormous boost in market share to the biomass industry.[40] The 2005 Energy Bill includes a Renewable Fuel Standard, which should do much to assist the further development of the biofuel industry, but similar measures are needed for the broader energy sector.

State incentive programs targeted for bio-based products. States too have a role to play in providing incentives and vision for renewable and bio-based production. Currently, 16 states and the District of Columbia have Renewable Energy Standards or Objectives, and many more are providing state funding and assistance to develop bio-based sectors within their respective states.

Minnesota, which has been a national leader in providing renewable fuels incentives, needs to follow the Federal government's lead and broaden its incentive programs to do more to include biorefineries and bio-based products. Whether through purchasing preferences that give priority to bio-based products, renewable energy standards, tax breaks for producers and marketers or targeted funding for further research, development and commercialization, a state investment could result in tremendous future benefits. Minnesota has provided support for these industries through such entities as the Agricultural Utilization and Research Institute, but its efforts need to be broadened and strengthened.[41]

Implementation of Minnesota's Biomass Mandate agreement in the spirit it was conceived can provide needed support to the establishment of integrated biomass energy systems. Another important avenue of support is technical assistance to farmers and biomass project developers. Farmers take on tremendous risk by growing new crops, purchasing new equipment and foregoing crop insurance programs for traditional crops. Providing guidance to these farmers can help lower these risks.

Minnesota's Governor, Tim Pawlenty, has recently proposed several initiatives that promote increased energy conservation, incentives for hybrid vehicles, and a requirement to increase ethanol content in gasoline sold in the state to 20 percent (it is currently 10 percent). Some Minnesota legislators have countered with their own proposals, including the creation of a Renewable Energy Standard for the state that would require that 20 percent of the state's electricity be produced from renewable resources. Programs such as these could provide needed incentives for further development of renewable and bio-based production in Minnesota, but they need to continue to be linked to local control and community issues.

Conclusion

The opportunity that a mature bio-based sector would provide in the way of jobs, valuable product commercialization, environmental protection, rural revitalization and reduced reliance on fossil fuels presents a strong rationale for public support and investment in research, development, product introduction and life cycle assessment. To justify public expenditures, however, the impacts and scale of bio-based production need to be continuously evaluated in order to assure that community and ecological benefits are indeed being gained along with economic returns. For farmers and rural communities in Minnesota and elsewhere, the potential of the bioindustrial sector is clear, and, in many cases, as detailed in the company profiles, at hand. It remains the duty of local, state, and federal government agencies along with citizens and advocacy groups to maintain the connection between the economic, social and environmental goals and to promote the sustainable development of this industry. Only through the realization of all of these objectives will the bio-based sector truly reach its potential for reviving agriculture and rural communities and providing new areas for economic growth and development. For Minnesota, which has so much to gain or lose from this new economy, the state needs to be involved in providing directed investment, support and guidance to assure that the bio-based sector grows in a way that provides real benefits to Minnesota farmers, businesses and communities.

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Useful Web sites and resources

The Agricultural Utilization Research Institute
http://www.auri.org/

The Carbohydrate Economy Clearinghouse
http://www.carbohydrateeconomy.org/

New Uses Council
http://www.newuses.org

USDA/DOE Biomass Research and Development Initiative:
http://www.bioproducts-bioenergy.gov/default.asp

U.S. Department of Energy, Energy Efficiency and Renewable Energy Program
http://www.eere.energy.gov/RE/bioenergy.html

Bio-Based Manufacturers Association
http://www.bio-based.com

Biological Materials for Non-Food Products (BIOMAT NET)
http://www.nf-2000.org/

American Bioenergy Association
http://www.biomass.org/

Clean Energy Resource Teams
http://www.cleanenergyresourceteams.org/home.html

Minnesota Sustainable Communities Network
http://www.nextstep.state.mn.us/

Minnesotans for an Energy Efficient Economy
http://www.me3.org

The Council of State Governments' Bio-based Products Page
http://www.csg.org/CSG/Policy/agriculture+and+rural+policy/bio-based+products/default.htm

National Renewable Energy Library Biomass Page
http://www.nrel.gov/biomass/

University of Minnesota Center for Biorefining
http://ox.bae.umn.edu/biorefining/

Environmental and Energy Study Institute
http://www.eesi.org

Biotechnology Industry Association
http://www.bio.org

Oak Ridge National Laboratory Bioenergy Information Network
http://bioenergy.ornl.gov/

Renewable Fuels Association
http://www.ethanolrfa.org/

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