MINNESOTA ROADMAP:

Recommendations for BioIndustrial Processing

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The BioBusiness Alliance of Minnesota™

with contributions by

BioIndustrial Partnership of Minnesota

GREAT PLAINS INSTITUTE

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Executive Summary

INTRODUCTION

The advanced biofuels and biobased chemicals industry is poised for rapid growth as the markets grow for alternatives to petroleum. Minnesota has an opportunity to be a global leader in bioindustrial processing and the emerging biobased products industry. The state can build from its current assets and channel its legacy in adding value to agriculture and forest resources.

For the last century, Minnesota has proven itself to be a global leader in the sustainable growth of the conventional biobased industry, including the manufacturing of food, feed, and fiber. In fact, sawmills and flour mills provided an initial basis for the economic growth of Minneapolis, St. Paul, and the rest of the state in the latter half of the 1800s. More recently, the state pioneered the development of the ethanol and biodiesel industry.

The capabilities and infrastructure of the conventional biobased industry provides a base to build upon for the growth of the emerging biobased industry. Minnesota companies will continue to see opportunities to secure investment for expansions into production of advanced biofuels and biobased chemicals.

Critical Definitions

Bioindustrial processing industry » The advanced biofuels and biobased chemicals industry, where industrial biotechnology is used to process biobased resources into valuable fuels and chemicals.

Conventional biobased industry » The industry manufacturing traditional agriculture and forest products such as food, feed and fiber and the value chain associated with manufacturing these products. Also includes the manufacturing of corn ethanol and soy biodiesel.

Emerging biobased industry » The industry manufacturing advanced biofuels, biobased chemicals, bioenergy, biopolymers, bioplastics and the value chain associated with manufacturing these products.

Renewable materials » The chemicals, biofibers, polymers, and materials that can be derived from renewable, biological resources including agriculture, forestry and other biobased resources.

Sustainable bioeconomy » Economy based on sustainable use of renewable resources to meet the growing food, material, and energy needs of the world.

Additionally, the state has already emerged as a leader in the growth of company headquarters within the biobased chemicals industry.

Background

The following roadmap is designed to provide a pathway to accelerate the industry's development. The report details factors influencing the development of the global advanced biofuels and biobased chemicals industry, identifies opportunity areas for Minnesota, and sets forth strategic recommendations.

The roadmap was developed under the guidance of The BioIndustrial Partnership of Minnesota, a group of businesses, government officials, and academics who are committed to realizing Minnesota's potential as the center of development for the advanced biofuels and biochemicals industries.

These efforts will accelerate industry growth, job creation, and value-added manufacturing that build upon Minnesota's agriculture and forest-based resources. These recommendations, if followed, can lead to the addition of 12,000 direct and indirect jobs in bioindustrial processing by 2025 across Minnesota, as detailed in Appendix E.[1]

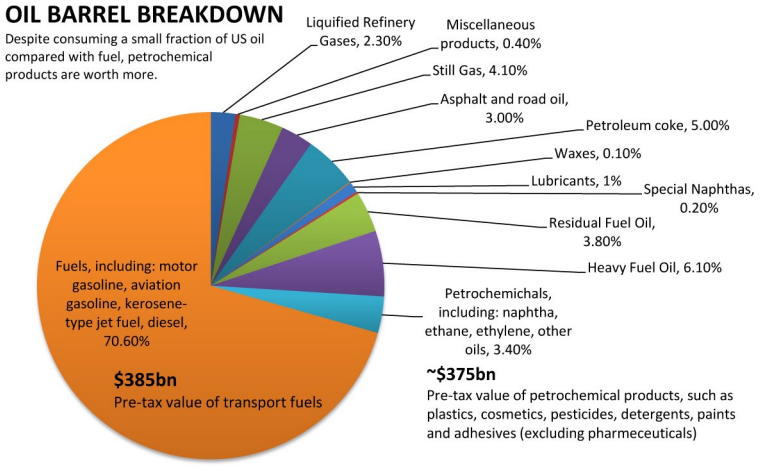
GLOBAL TRENDS

Factors influencing industry development

Advanced biofuels and biochemicals combine forces in a drive to replace the whole barrel of oil – not just fuels. In today's oil refinery industry, 3 percent of the volume of feedstock is used for a wide array of chemicals, while another 70 percent is used for fuels. However, the total revenues from each category are equal. For this reason, industry development for the emerging biobased industry must proactively include the production of biobased chemicals, as well as biofuels, in order to create maximum value.

However, years of research and development and commercial development will be required before a product in the emerging biobased industry can be viable in the marketplace, creating significant high-technology jobs. Additionally, manufacturing of advanced biofuels and biobased chemicals is capital intensive, making it important to ensure funding availability across the spectrum. The opportunity is large for successful companies, however.

Partnerships are critical factors to consider in the growth of companies in the emerging biobased economy. Categories of partnership will include



SOURCE: U.S. DEPARTMENT OF INDUSTRY 2005, AMERICAN INSTITUTE OF CHEMISTRY

Figure 0.1, Oil Barrel Breakdown into Products

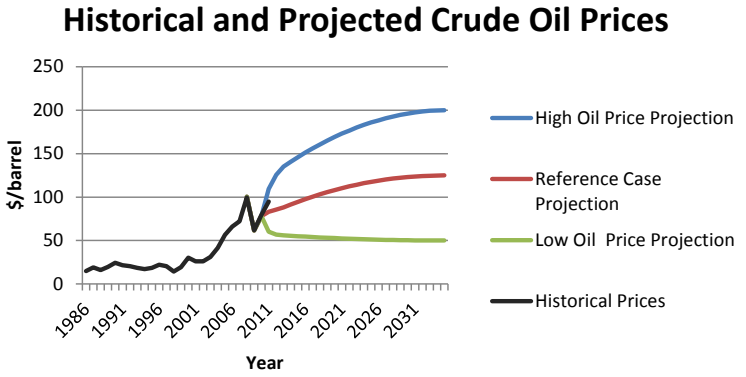


Figure 0.2

Composite of Petroleum Product Prices, Reference Case, High Oil Case, and Low Oil Price Case. (2011) US Department of Energy: Energy Information Administration. Annual Energy Outlook. Imported Low Sulfur Light-Crude Oil. Retrieved February 10, 2012 from http://www.eia.gov/oiaf/aeo/tablebrowser/

Historical data from *Spot prices from crude oil and petroleum products*. (2012). Retrieved February 14, 2012, available from: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm

- Downstream buyers of products, to ensure that a market exists for biobased chemicals, and
- The conventional biobased industry, to minimize capital requirements and ensure biomass supply.

Downstream market development: Biobased chemicals

Biobased chemicals are being used in an increasing array of products, including everyday items such as plastics and cleaning agents.

The global market value of biobased chemicals is projected to reach $483 to $614 billion across a broad range of chemicals by 2025, as detailed by the USDA.[2] This represents more than a 20 percent market share of the global chemicals industry.[3] A variety of factors are driving growth in market demand.

First, petroleum prices are on a long-term upward trajectory, in part due to the increasing difficulty of extraction and transportation of crude oil. Between 2000 and 2010, the average cost of bringing a new oil well to production doubled.[4] For chemicals dependent on petroleum-based feedstocks, supplies have been squeezed, and as a result, prices have increased. These market dynamics are creating an opportunity for biobased chemicals to provide a cost-effective alternative.[5]

Additionally, consumer demand is growing for safer, more environmentally friendly products. Chemical regulation is becoming more stringent, and renewable materials that perform well in final products are helping fill the market's demand for safer materials. These products provide clear value to their customers in terms of functionality and sustainability.

Downstream market development: Biofuels

Global demand for biofuels is projected to increase from $82.7 billion in 2011 to $185.3 billion by 2021.[6] Policies requiring consumption of advanced biofuels across the globe continue to be implemented, and over time, these will likely continue to result in increased requirements for environmental performance. Additionally, development of the technology and required supply chains for cellulosic biofuels are expected to advance quickly.

Agriculture supply chain development

The conventional biobased industry stands to benefit significantly from additional markets, revenue, and profit that bioindustrial processing can provide.

Agriculture is well-positioned to meet increasing demand for food, feed, fiber, and fuels. Growth in yields for existing crops can enable the growth of new markets to utilize agricultural feedstocks, even while meeting existing demand. Additionally, the harvesting of agricultural residues will lead to added value from the land. In some cases, new crops will be developed for industrial purposes, such as diversified prairie grasses and energy beets. Bioindustrial processing could have profound impacts on agriculture production.

Forestry supply chain development

The forest products industry has been battered by economic turmoil in the past five years. Declining forest products output, and the resulting decline in timber production in Minnesota, has resulted in a systematic underutilization, an inability to manage some areas of the forest, and lost economic

activity. Advanced biofuels and biobased chemicals provide an opportunity for growth that leverages existing infrastructure, established supply chains, and Minnesota's rich forest resource.

MINNESOTA'S STRENGTHS

The state's bioindustrial processing industry is strong and growing, and Minnesota's economy has an opportunity to benefit from its development.

Minnesota is well on its way to being a global leader in bioindustrial processing. Within the state, companies are supported by research and education from world-class universities, a supportive public sector, and a strong history for industry creation in the development of the first generation ethanol and biodiesel industries. Additionally, there are four general categories of strengths listed below.

1. Emerging cluster of bioindustrial processing company headquarters

The state has a critical mass of companies on the cutting edge of the development and implementation of new bioprocessing technologies. The state continues to drive toward the development of a sustainable industry cluster. Nearly 2,000 direct and indirect jobs have already been created through this economic activity.

The availability of talent is among the primary reasons for the growth of this new cluster, along with local biomass resources. Minnesota has

- Experienced executives in an array of biobased industries,
- Scientists and engineers with superior expertise in the production and conversion of biobased feedstocks, as well as the design and manufacturing of final products, and
- Accomplished service providers, such as lawyers, engineers, and accountants.

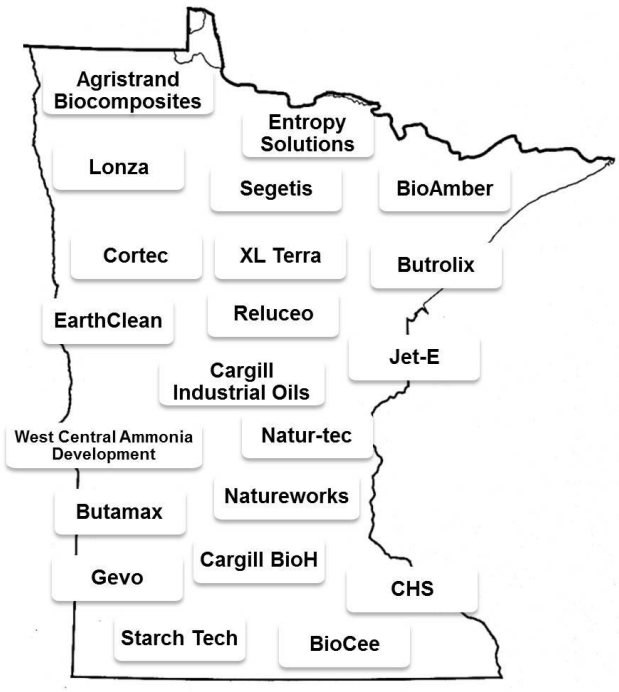


Figure 0.3, BioIndustrial Processing Companies with headquarters or major operations in Minnesota
The map is intended as a list, not an indication of location.

Assuming Minnesota's industry can grow at a rate similar to global market growth, direct and indirect employment in bioindustrial processing company headquarters is projected to total 7,000 by 2025.[7]

2. Feedstocks

Another advantage for Minnesota is that the state has sufficient agricultural and forest resources available to provide a diverse set of feedstocks for manufacturing advanced biofuels and biobased chemicals. Key assets include:

- Strong agriculture production. The state ranks fourth in the nation for production of corn, and third in the nation for soybeans, and is the top producer of sugar beets.
- At least 3.2 million green tons of surplus wood available in northern Minnesota.[8]

3. Existing infrastructure

A third advantage for Minnesota is the state's strong conventional biobased industry, which provides necessary infrastructure for integrated biorefinery development. Facilities in the ethanol, biodiesel, and forest products industry have the potential to develop additional revenue streams. In partnership with the emerging biobased industry, existing biorefinery infrastructure can be repurposed for the advanced biofuels or biobased chemicals markets, which is the case for three shuttered oriented strand board (OSB) facilities in northern Minnesota.

The manufacturing of advanced biofuels and biochemicals could result in the employment of over 6,000 people by 2025 in a combination of partnerships with existing biorefineries as well as new construction. The impact for rural communities in Greater Minnesota could be considerable, just as it was in the recent emergence of the conventional biofuels industry.

Figure 0.4, Minnesota's ethanol, biodiesel, pulp and paper mills, large sawmills, and engineered wood products facilities

4. Established base of large companies in related industries

Finally, Minnesota is home to 20 Fortune 500 companies.[9] Several of these large companies could be drivers in the value chain for renewable materials, including Cargill, 3M, Ecolab, H.B. Fuller, Target, and CHS.

Within these companies exist established capabilities that could be leveraged to provide logistics systems for commodity supply chains, formulation and manufacturing of products using biobased chemicals and biobased intermediates, and distribution and sales of goods to end users. Mutually beneficial relationships along this value chain can solidify the favorable market position of downstream partners, while enabling growth in the advanced biofuels and biobased chemicals industry.

A STRATEGY FOR MINNESOTA

Given Minnesota's advantages in resources, knowledge, and infrastructure, industry development is expected to occur across all stages of company growth, from early-stage development through manufacturing scale-up and global market growth.

The following strategies provide a roadmap to allow Minnesota to realize its potential as a world leader in bioindustrial processing.

1. **Ensure availability of funding options for bioindustrial processing**

   Financing will be of critical importance to the industry. A full spectrum of investment is needed, from seed and angel funding to venture capital and long-term debt capital. Tactics include:

   - Educating investors and financial institutions about the unique opportunity to develop the bioindustrial processing industry in this region, and
   - Ensuring awareness, availability, and access to federal and state financial support to accelerate research and development through full-scale manufacturing

2. **Communicate Minnesota's competitive advantages to the global industry**

   Minnesota's unique combination of assets provides opportunities to actively position the region and individual biorefineries as strong places to develop business opportunities. Other geographies are aggressively competing in this space, including other U.S. states, Brazil, and Southeast Asia. Outcomes would include the attraction of companies, business leadership, and investment.

   A second tactic would be to provide support to individual facilities that have the desire and financial interest in partnering with advanced biofuels and biochemicals companies. Identification of viable partners and navigation of federal policy programs are two major areas of need.

3. **Enable production and development of end markets for bioindustrial processing**

   Continued improvement of the regulatory environment in Minnesota is critical for the development of manufacturing in the state. Adjustments in policies must be designed to include considerations to accelerate speed of time to market and minimizing costs for companies. Additional details are provided in the policy section of this document.

   Furthermore, policies must be developed in a fashion that ensures inclusivity for all types of biofuels. This can ensure the overall biofuels market continues to grow for various applications.

   For renewable materials, education will play a role in ensuring that parties across the value chain understand the factors behind demand. For example, a manufacturer who understands how to take advantage

of market growth from green-conscious consumers, perhaps through the use of biobased materials, can stand to benefit significantly from new market opportunities.

4. **Organize industry-led efforts to develop a voice for the industry**

   Successful implementation of the strategy described above will rely on the development of a stable voice for the industry. The focus of the organization would be industry growth.

   Harnessing collective efforts to develop and communicate clear and concise messages can raise the profile of bioindustrial processing, providing multiple benefits in terms of developing supportive policies and driving investment and business partnerships to the industry.

CONCLUSION

The advanced biofuels and biobased chemicals industry is set for strong growth, and Minnesota has the assets to sustain a global leadership position. Implementation of the prior recommendations will serve to accelerate this growth.

ENDNOTES

1. BBAM analysis. Includes direct and indirect employment. Please see Appendix E for detailed explanation.
2. A majority of this value is derived from specialty and fine chemicals. *U.S. biobased products market potential and projections through 2025.* (2008) Washington DC: U.S. Department of Agriculture, Office of the Chief Economist. OCE-2008-1. February 2008. Retrieved on March 12, 2011 from www.usda.gov/oce/reports/energy/biobasedreport2008.pdf.
3. *U.S. biobased products market potential and projections through 2025.* (2008) Washington DC: U.S. Department of Agriculture, Office of the Chief Economist. OCE-2008-1. February 2008. Retrieved on March 12, 2011 from www.usda.gov/oce/reports/energy/biobasedreport2008.pdf.
4. Dobbs, R. et. Al. (2011) *Resource Revolution: Meeting the world's energy, materials, food, and water needs*. McKinsey Global Institute, McKinsey Sustainability & Resource Productivity Practice. Pg 45. November 2011. Retrieved on November 23, 2011 from http://www.mckinsey.com/en/Features/Resource_revolution.aspx.
5. Additional details in Downstream Market Development-Biobased Chemicals. Production has shifted to a reliance on natural gas feedstocks, squeezing the market for certain petrochemicals.
6. Pike Research, Inc. (2011). *Global biofuels market value to double to $185 billion by 2021.* October 11, 2011. Retrieved on February 27, 2012, from http://www.pikeresearch.com/newsroom/global-biofuels-market-value-to-double-to-185-billion-by-2021.
7. BBAM analysis. Includes direct and indirect employment. Please see Appendix E for detailed explanation.
8. Deckard, Don. (2010) Economic Opportunities for Minnesota's Wood. Unpublished Document. May 2010. The surplus assumes a small reserve capacity to remain in the forest for market stability.
9. *Fortune 500 Ranking of America's Largest Corporations (2011).* CNN. Retrieved on October 1, 2011 from http://money.cnn.com/magazines/fortune/fortune500/2011/states/MN.html.