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WISCONSIN'S BIOBASED INDUSTRY: OPPORTUNITIES AND ADVANTAGES STUDY

Volume 1: Briefing Paper

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INTRODUCTION

Across the globe, countries and regions are looking to the "bioeconomy" as the economic development wave of the future. The bioeconomy – an economy based on industries and technologies that turn organic matter ("feedstocks" or "biomass") into energy, fuel, and products such as chemicals or plastics – presents a compelling short-term economic development opportunity because it focuses on turning a region's existing crops and waste streams into higher-value products, rather than on bringing a host of entirely new industries into the region. In the longer term, as new technologies and processes are discovered, the bioeconomy can provide regional opportunities for entrepreneurship, innovation, research and development.

This type of economic development strategy has tangible benefits for the farmers and foresters who grow the biomass, but also for those involved in the biomass processing (such as turning corn into ethanol) and product development (such as creating solvents and plastics from biobased, rather than petroleum-based, chemicals). The economic ripple effects of a bioeconomy can reach even further, to a host of support industries such as construction, transportation, and manufacturing, and even to incidental industries in the retail and service sectors.

These economic opportunities are only part of the picture, however. The vision of a bioeconomy is based on a fundamental shift away from fossil fuels and toward locally-grown biomass as the raw material for energy, fuel, and chemical production. This shift will provide dramatic environmental benefits to regions that pursue bioindustry development, both because it will reduce the greenhouse gas emissions endemic to oil and gas combustion, and also because it will funnel resources toward developing more energy-efficient and sustainable feedstocks. Moreover, if the processes used to turn feedstocks into higher-value products can be done at a small scale, plants may be able to move closer to the source of the feedstocks, thus further reducing fossil fuel emissions (as well as transportation costs).

Additionally, moving away from imported fossil fuels will increase national security and reduce commercial instability caused by shortages and energy price fluctuations. The more the U.S. depends on overseas oil, the more vulnerable we are to an oil shortage caused by an overseas civil war, terrorist attack, or other event outside our control; furthermore, sending oil payments to unstable countries may actually indirectly fund insurgent activities in those countries. For our economic and political stability, it is crucial that the U.S. seriously explore any avenue that will make this country less dependent on outside sources of oil. Diversifying our energy and fuel resources to include more domestic, biobased production is one key way to move toward this independence.

For all these reasons, it is time for Wisconsin to take a serious look at the state's potential to participate, and become competitive, in the emerging bioeconomy. In this paper we take a first broad look at that potential. We first provide an overview of the bioeconomy, and contrast this with the fossil-fuel based economy; this overview includes a discussion of the mix of environmental, economic, and equity factors that make up a truly successful bioeconomy. We then briefly discuss global, national, and Midwest bioeconomy efforts, including policies that may affect Wisconsin's decision to move in this direction.

The second half of the paper is dedicated to exploring Wisconsin's potential place in the bioeconomy. Because the short-term bioeconomy potential lies in the state's existing resources

and infrastructure, we focus in on the state's current land use patterns, agricultural and forestry operations, and workforce trends. We also provide an overview of the industries in which the state has high concentrations of employment, and discuss which of these are most likely to be involved in the state's bioindustry "cluster." Finally, looking toward the future, we discuss the state's existing strengths in education, research and development, and workforce and economic development. These institutions will provide the foundation from which the state can pursue the cutting-edge technologies of the bioindustry future.

This paper is intended to paint, in broad strokes, the background for the Wisconsin bioeconomy picture. To fill in some of the details, we will provide a companion Technical Study dedicated to exploring the specific feedstocks currently grown in Wisconsin, and their potential to anchor various bioindustry processes. Taken together, the Briefing Paper and the Technical Study point toward a key conclusion: in order to create a successful bioeconomy, Wisconsin must not only build on its existing resources and infrastructure, but must also pursue specific policies targeted toward creating an economy that includes a range of rural and urban jobs, entrepreneurship opportunities, ownership opportunities for rural landowners, and economic incentives balanced with environmental protections. Accomplishing this task will require the state to efficiently organize its existing feedstocks and technologies in the short term, so that the state is fully in step with its neighbors in harnessing current bioindustry opportunities. In the longer term, Wisconsin must organize its many high-quality institutions – government, academia, business, labor, and community – to provide a strong, robust foundation for research and development into the as-yet-unknown bioindustries of the future. Our third paper, a set of Policy Recommendations, directs the state toward this path.

Building a successful bioeconomy, one that capitalizes on existing strengths but also builds a foundation for future developments, is a huge task – but it is a task that could result in a cleaner, more stable, more secure, more prosperous Wisconsin. Therefore it is a task that we feel the state cannot afford to ignore.

THE BIOECONOMY: BACKGROUND AND CONTEXT

What is the Bioeconomy?

When we talk about the potential for Wisconsin to develop a "bioeconomy," what exactly do we mean? Essentially, a bioeconomy is an economy made up of industries that rely on renewable biobased feedstocks as their raw material. Just as the fossil fuel economy – including oil and gas extractive industries, petrochemical industries, transport of oil and gas in liquid form, transmission of coal energy through power lines, etc. – relies on the raw materials of coal, oil, and natural gas, so does the bioeconomy rely on the raw materials of plants, crops, wood waste and animal waste.

Like the fossil fuel economy, the bioeconomy has many facets and many potential industry offshoots. It is perhaps best understood by looking at the three stages of industry development: the raw product, or the biomass feedstocks themselves; the processes used to convert the feedstocks into a higher value-added product; and the final products produced by those processes. (Note: this section relies heavily on the work done by the Wisconsin Biorefining Development Initiative, whose website, www.wisbiorefine.org, provides a very detailed discussion of the relationships among feedstocks, processes, and products in the bioeconomy, as well as an in-depth look at Wisconsin's available biomass resources and technologies.)

Feedstocks: At the root of the bioeconomy lies the raw material: biomass feedstocks. The sugars, starches, oils, fibers and other organic materials that are produced by living plants and animals can be transformed into higher value products such as energy, fuels, and biobased products such as chemicals and plastics. Feedstocks include crops such as alfalfa, soybeans, and corn; perennials such as switchgrass; crop and forest residues; and animal wastes such as manure from cows, pigs, and poultry. Secondary feedstocks – those that are produced as waste matter when a primary feedstock is processed – can also sometimes be used as raw materials in the bioeconomy: these include, for example, pulp and paper mill waste, food and meat processing waste, brewery waste such as spent grains and hops, and municipal solid wastes.

Processes: Most of these feedstocks have only minimal value on their own, so a major goal of the bioeconomy is to find processes that transform them into something of higher value, such as energy or fuel. These processes can range from the very simple (e.g. burning wood to create heat energy) to the very complex (e.g., processes used to create chemicals and plastics from biomass, such as pyrolysis and thermochemical liquefaction).

Products: The products created through these processes fall into three groups: bioenergy, biofuels, and bioproducts. "Bioenergy" refers to the process of converting biomass into electricity and heat, or "energy," sources. For instance, plant matter and woody waste can be cofired with coal in traditional power plants, and anaerobic digestion can produce a biogas that acts similarly to natural gas. "Biofuels" are renewable fuels intended to displace transportation fuels, and include ethanol and biodiesel. Ethanol is generally made from corn and other sugar crops, though new processes are being developed to produce ethanol from the cellulose found in switchgrass, woody waste, and wheat straw. Biodiesel is generally made from oils found in soy, canola, and rapeseed.

The third large potential market for biomass is in "bioproducts" – replacing products that are typically petroleum-based, including many chemicals and plastics, with biobased products. Scientists have realized that the same process that is used to create biofuels – releasing and fermenting the sugars that make up the starch and cellulose in plants – can also be used to create a number of commercial products, such as antifreeze, plastics, and glues. Other bioproduct processes include heating biomass without combusting it, which can create products such as biosynthesis gas that, in turn, can be used to make plastics and acids. Similar processes can produce pyrolysis oil, from which chemicals such as phenol – the basis for many adhesives, molded plastics, and foam insulation – can be extracted.

Why BioIndustry?

Before embarking on a discussion of existing biobased initiatives across the world, and Wisconsin's potential to develop a strong bioeconomy of its own, it is important to step back and ask the question: Why? Why is there so much interest in using existing feedstocks to create bioenergy, biofuel, and bioproducts? While the answer to this question is complex, most arguments for investing in the emerging bioeconomy fall into the following general categories:

Energy Independence. Since the 1970s and especially since 9/11, many oil dependent nations have become increasingly aware of the instability of the world oil market, and have begun to think seriously about ways to move away from dependence on fossil-based petroleum. If countries can replace some of their petroleum imports with domestic biomass products, they can move toward greater independence from unstable, often politically hostile oil-producing countries in the Middle East and elsewhere. In the short term the bioindustry is unlikely to have more than a marginal impact on the overall energy and fuel supplies of Wisconsin's economy. However, by providing bioenergy and biofuel at the margins of supply and demand, the bioeconomy can add value to domestically produced feedstocks while taking an important first step toward greater energy independence.

Rising Fuel Costs. In a similar vein, many regions are working to replace a portion of their transportation fuel with biofuels (primarily biodiesel and ethanol, but potentially also biobased hydrogen), in order to insulate their economies from the rising cost of fuel. In the U.S., for instance, retail gasoline prices have risen 49 percent in the past year alone, while diesel prices have risen over 59 percent.[1] These dollars have flowed mostly to foreign countries, because the U.S. is a net importer of oil: currently only three percent of the world's oil reserves are located in the United States, while we consume roughly 25 percent of the oil available in today's market. Most of these oil reserves are considered "marginal" wells, meaning that they produce fewer than ten barrels of oil per day. [2] Thus the U.S. depends on imported oil in order to maintain consumption. Replacing a percentage of U.S. fuel with locally-grown biofuel would insulate the United States economy from some of the price fluctuations of the worldwide oil market.

Regional Economic Development. Relying more heavily on locally-produced bioenergy and biofuel would also allow millions of dollars in biomass-producing states to be reinvested in

[1] From http://tonto.eia.doe.gov/oog/info/twip/twip.asp (released Aug. 10, 2005).
[2] Energy Information Administration, *Country Analysis Briefs* (January 2005), available at http://www.eia.doe.gov/emeu/cabs/usa.html.

those state's economies. Wisconsin, for example, consumed 6.8 million gallons of gasoline per day in 2001 (see Table 1). If gasoline cost about $2/gallon that year, which becomes approximately $1.30 when you account for taxes and distribution and marketing costs[3], then the state sent over $8.8 million per day to other states and countries to pay for that gasoline, and much more to pay for imported natural gas and energy fuel. More broadly, a successful biobased economy translates into direct employment opportunities for residents of states and countries with biomass reserves. These regions should see direct employment opportunities in biomass growing, harvesting, processing, transportation and sale, as well as in construction and installation of new processing facilities. Higher-skilled workers will also find opportunities in the research and development necessary to discover new and better bioenergy, bioproducts, and biofuel opportunities. Every new job created by the emerging biobased industry translates into money that will be reinvested by workers back into the regional economy, creating jobs in other industries such as services, retail, and home construction.

Benefits to Farms and Forestry Industries. Because farms and forests are the places where most biomass is generated, they are crucial to the emerging biobased economy. Revitalizing these industries, which have been hard hit by fluctuating prices, is a priority for many regions in the world; the expectation is that the biobased economy will provide a new market for existing crops and forest industry residue, as well as for future crops.

Environmental Benefits. Replacing petroleum-based products with biomass in the energy, fuel and chemical product sectors, especially where the biomass comes from local sources, should decrease carbon and other emissions over time, particularly as new and more efficient technologies are developed. A new market for biomass crops will allow farmers and forestry operators to maintain farms, forests, and other open lands, rather than selling them for housing or commercial development. Even greater benefits would be realized from a carbon trading regime such as that in place in Europe; this could add major new sources of revenue to the bioindustry.

Technological Innovation. The biobased economy is in the very early stages of development in most countries. Promoting policies that encourage biomass production and secure the market for new bioenergy, biofuels, and bioproducts will spur entrepreneurship and innovation in these industries. If Wisconsin aggressively pursues its opportunities in the biobased economy, the state will be in a position to lead the nation – and perhaps the world – on emerging technologies such as bio-based chemicals and biofuels such as cellulosic ethanol.

[3] "A Primer on Gasoline Prices." US Energy Information Administration, 2005. http://www.eia.doe.gov/bookshelf/brochures/gasolinepricesprimer/eia1_2005primerM.html

Table 1: Wisconsin's Fossil Fuel Consumption

		State Rank
Population	**5,509,026 (2004)**	**20**
Per Capita Income	**$32,157 (2004)**	**22**
Total Energy Consumption	**1.9 quadrillion Btu (2001)**	**19**
Per Capita Energy Consumption	**345 million Btu (2001)**	**25**
Total Petroleum Consumption	**14.4 million gallons per day (2001)**	**20**
Gasoline Consumption	6.8 million gallons per day (2001)	20
Distillate Fuel Consumption	3.6 million gallons per day (2001)	16
Liquefied Petroleum Gas Consumption	1.2 million gallons per day (2001)	10
Jet Fuel Consumption	0.3 million gallons per day (2001)	32
Total Natural Gas Consumption (volume delivered to consumers)	**391,186 million cubic feet (2003)**	**N/A**
Residential	142,067	N/A
Commercial	87,131	N/A
Industrial	137,605	N/A
Vehicle Fuel	253	N/A
Electric Power	24,130	N/A

Source: U.S. Energy Information Agency (http://tonto.eia.doe.gov/oog/info/state/wi.html)

The Significance of the Oil and Gas Industry to Bioindustry Potential

No discussion of the world biomass industry would be complete without a brief overview of the state of the raw materials that currently dominate the energy, fuel, and chemical markets: oil and natural gas. Though many people think of oil and gas as synonymous with transportation fuel, in fact they are also key inputs in energy production (much of which is fueled by natural gas) and in the manufacture of a huge range of commercial products derived from petroleum (everything from pesticides to fertilizers to chewing gum to synthetic carpets). The price fluctuations in the oil and gas markets, the risk associated with potential long-term scarcity of affordable oil, the environmental harms caused by overdependence on fossil fuels, and the national security dangers brought on by overdependence on foreign oil are all key factors supporting the emerging biobased economy.

Oil

Oil is the single largest source of energy in the world. From 1900 to 1973, global oil consumption grew at a rate of seven percent, meaning that consumption doubled every ten years. Currently, oil accounts for roughly 40 percent of global energy consumption and 96 percent of transportation energy consumption; the United States is responsible for one quarter of this consumption.[4] And consumption is growing: in 2004, global oil consumption grew 3.4 percent, or 2.5 million barrels a day – the fastest growth rate since 1978.[5] Global oil consumption is expected to increase to 119 million barrels per day in 2020, which is about 44 million barrels per day over current production capacity.[6]

[4] U.S. Department of Energy, *Fossil Fuels*, available at http://www.energy.gov/engine/content.do?BT_CODE=FOSSILFUELS (last visited June, 27 2005).

[5] *Oil in Troubled Waters*, The Economist, April 28, 2005. Note that when the rate of consumption of a resource is growing at a fixed percent each year, growth is actually exponential. When the rate of growth is 7 percent per year, for instance, consumption in one decade will exceed the total of **all previous consumption**.

[6] Business Communications Co., Inc., *Energy Industry Review* (2002), available at http://www.the-infoshop.com/study/bc11538_energy_industry.html.

Developing countries are driving this dramatic growth in oil demand, primarily because their economies are growing at a faster rate than the developed world. According to UN projections, 81 percent of the world's population will be living in developing regions by 2030.[7] China and India, with their vast populations and massive economic development efforts, are leading contributors to the global rise in energy demand. China has become the second leading consumer of oil in the world, and its oil use is expected to grow at a rate of 7.5 percent per year.[8] By 2030, the International Energy Agency projects that China will import as much oil as the U.S. does now – an eightfold increase over China's current import levels.[9] As China's need for imported oil increases, so will its dependence on the Middle East, as 58 percent of China's imported oil comes from this area. India is not far behind, with consumption growing by 5.5 percent per year.[10]

In all regions of the world, the largest increase in oil consumption is expected to result from oil's use as transportation fuel. The most significant cause of the increasing energy consumption associated with transportation is the growing global reliance on private cars. Nearly 40.6 million passenger-vehicles rolled off the world's assembly lines in 2002, five times as many as in 1950. The global passenger-car inventory now exceeds 531 million vehicles, growing by about 11 million vehicles annually. About one fourth of those cars are found on U.S. roads, where cars and light trucks account for 40 percent of the nation's oil use.[11] As a result of these vehicle trends, as well as increased commuting times and increases in the size of U.S. residences, oil use in this country has increased over the last decade by nearly 2.7 million barrels a day, which is more oil than is used daily in total in India and Pakistan (these two countries combined contain more than four times as many people as the United States).[12]

As consumption rises, some observers believe that the oil supply has stagnated: the discovery rate of new oil resources worldwide peaked in 1962, and some estimates suggest that global oil output is likely to peak soon, perhaps even within 10 years, and then drop off sharply.[13] Even if oil peak predictions are overstated, however, it seems clear that the drastic rise in oil consumption across the world will certainly lead to a corresponding rise in prices.

Moreover, many of the oil-producing countries are vulnerable to political events and natural disasters that can significantly affect oil prices, making them even more unstable and unpredictable. As previously discussed, the U.S. depends on imported oil in order to maintain consumption. Roughly 60 percent of the oil used in the U.S. is imported from the Middle East and other politically unstable nations such as Algeria, Nigeria and Venezuela, meaning that we

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[7] Jaffe, Amy, Wallace Wilson, James A. Baker III, *The Growing Developing Country Appetite for Oil and Natural Gas*, USPolicy.be (May 5, 2004), available at http://www.uspolicy.be/Article.asp?ID=DA068E8B-985E-44E0-9EAE-6E5F384066AB.

[8] Britt, Robert Roy, *End of Oil Could Fuel 'End of Civilization as We Know it.'*, LiveScience (December 14, 2004), available at http://www.livescience.com/environment/end_oil_041214.html.

[9] Institute for the Analysis of Global Security, *Energy Security, a*vailable at http://www.iags.org/energysecurity.html (last visited June 27, 2005).

[10] Britt, *supra* note 8.

[11] Deffeyes, Kenneth S., HUBBERT'S PEAK: THE IMPENDING WORLD OIL SHORTAGE (Princeton University Press: 2002).

[12] O'Lear, Shannon, *Disengagement: The Oil Question*, Swords and Ploughshares, Vol. XIV, No.3 (Winter 2002).

[13] Deffeyes, *supra* note 11.

are essentially dependent on these often hostile countries for our current standard of living.[14] Experts anticipate that if the United States continues its current consumption trends, dependence on foreign oil – and the national security concerns that go hand-in-hand with this dependence – will only increase. As the Institute for the Analysis of Global Security and others have pointed out, dependence on overseas oil makes this country more vulnerable to oil shortages and price fluctuations caused by factors beyond our control, such as civil wars or terrorist attacks. Additionally, when the U.S. sends oil payments to politically unstable countries, we may be directly funding such terrorist activities.[15]

Whether oil production will peak, demand will outstrip supply, or vast new sources of petroleum will emerge are questions currently debated around the world. However, even those who are skeptical about global oil supply limits must admit that dependence on foreign oil fosters instability, and also that oil prices are rising fast. Traders speculate that the high prices are due to a combination of high demand, various U.S. refinery breakdowns, political factors (e.g. Iran's decision to resume uranium conversion practices), and speculation.[16]

Natural Gas

After oil, the second leading source of global energy is natural gas, used to generate electricity for industrial, residential, and commercial buildings, and also used as a transportation fuel in about two million vehicles worldwide.[17] Altogether, natural gas accounts for nearly 25 percent of global energy consumption.[18] North America, the Former Soviet Union, and Europe combined are responsible for 75 percent of global natural gas consumption, with the United States leading the pack with 27.2 percent of total consumption.[19] The industrial sector accounts for the greatest proportion (about 32 percent) of natural gas use in the United States, with electricity generation coming in second (24 percent).[20] Natural gas-powered electricity is predicted to increase dramatically over the next 20 years, at a rate faster than all other energy sources (coal, nuclear, renewable, and petroleum), and at twice the projected rate of increase in oil consumption.[21] This projected increase is partly attributed to fears about declines in oil reserves, but mainly related to the fact that natural gas is environmentally superior to oil, and potentially less costly.

In contrast to oil, the United States relies heavily on domestic production of natural gas: 84 percent of natural gas consumed by the U.S is produced in North America, while the remainder is imported either by pipeline from Canada, or as Liquid Natural Gas (LNG) from

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[14] Miller, Gary, *Reducing U.S. Dependence on Foreign Oil* (June 2, 2004), available at http://www.house.gov/garymiller/ReducingForeignOilDependence.html.
[15] Institute for the Analysis of Global Security, http://www.iags.org/saf.html.
[16] Tran, Mark, Oil *prices hit new heights*, Guardian Unlimited, August 12, 2005.
[17] NaturalGas.org, *Natural Gas Demand* (2004), available at http://www.naturalgas.org/business/demand.asp).
[18] Energy Information Administration, *Annual Energy Outlook 2005* (April 13, 2005), available at http://www.eia.doe.gov/oiaf/aeo/gas.html.
[19] Energy Information Administration, *Natural Gas Consumption* (March 2003), available at http://www.eia.doe.gov/neic/infosheets/natgasconsumption.htm.
[20] NaturalGas.org, *Uses of Natural Gas* (2004), available at http://www.naturalgas.org/overview/uses.asp.
[21] NaturalGas.org, *Electric Generation Using Natural Gas* (2004), available at http://www.naturalgas.org/overview/uses_eletrical.asp; see also Energy Information Administration, *International Energy Outlook 2004* (May 27, 2004), available at http://www.eia.doe.gov/oiaf/ieo/nat_gas.html.

Trinidad/Tobago and several other countries.[22] But like oil, natural gas prices are going up. This is due in part to high oil prices, which cause some producers who can switch between oil and gas to move over to gas, thus driving up demand (and price). However, a potentially larger problem is that natural gas, like oil, may be running out. The ratio of reserves to production is declining in Canada, and storage levels are at their lowest recorded levels.[23] These factors combine to push the price of natural gas steadily upward: in the winter of 2005, the EIA estimates that U.S. households heated primarily with natural gas will spend about $350 (48 percent) more in fuel expenditures than the previous year.[24]

Potential Impact of the Bioeconomy on the Fossil Fuel-Based Economy

The case for moving away from a costly and unstable – not to mention potentially dangerous – petroleum economy is clear; the question remains whether investing in the bioeconomy will really allow Wisconsin, and the U.S. as a whole, to gain any actual independence from fossil fuels. In short, how much of the enormous, growing fossil fuel economy can realistically be displaced by bioindustry?

A recent study from the U.S. Department of Energy (DOE) and the Department of Agriculture (USDA) attempts to answer this question.[25] The study authors found that to displace 30 percent of current U.S. petroleum use in energy, fuel, and other products – a goal set by the two agencies in a 2002 vision paper[26] – the country as a whole would need to produce 1.3 billion dry tons of biomass per year. Current cropland and forests, excluding environmentally sensitive and roadless areas, have the potential to produce this much biomass, but this would require a seven-fold increase in production, some changes from annual crops toward more efficient perennial energy crops, and more efficient harvesting of waste. Additionally, transforming the biomass into useable energy, fuel, and other products would require a massive increase in bioenergy and biorefinery facilities across the country. The upshot, though, is that 30 percent replacement of petroleum with domestically grown and processed biomass is not a pipe dream.

Rising demand, rising prices, and growing instability in the oil and natural gas markets are all important factors in the case for a bioeconomy. Rising demand indicates a growing global market for alternative fuels. Rising costs also spur that market, and – perhaps more important at the local level – make long-range transport of feedstocks more difficult, and therefore encourage locally-based, smaller bioenergy and biofuel facilities. And growing instability builds the political case for a more secure, more domestic energy and fuel supply. In this context, it makes sense for Wisconsin to invest in a local strategy, based on local raw materials such as agricultural and woody biomass. Moreover, it is clear that other regions will increasingly look to similar solutions to the global energy consumption/supply problem; Wisconsin may provide a model for these regions in the future.

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[22] Seventy-five percent of the U.S. imported LNG is from Trinidad/Tobago; the remainder comes from Algeria, Nigeria, Qatar, Oman, and Malaysia. EIA *Natural Gas Monthly*, August 2004.
[23] W.J. Simpson, *Supply crisis looms*, Petroleum Economist, July 2003.
[24] EIA, Short Term Energy Outlook, at http://www.eia.doe.gov/emeu/steo/pub/contents.html (Aug. 9, 2005).
[25] Perlack, Robert D. et al, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-Ton Annual Supply* (Joint study by the DOE and USDA, April 2005), available at http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf.
[26] DOE, *Vision for Bioenergy and Biobased Products in the United States* (October 2002), available at http://www.bioproducts-bioenergy.gov/pdfs/BioVision_03_Web.pdf.

Elements of a Successful Bioeconomy

The remainder of this paper will examine bioeconomy efforts in other countries and states, and will discuss Wisconsin's strengths and weaknesses as a bioindustry hub. To frame these issues, it is useful to consider what a successful bioeconomy might look like in Wisconsin. Beyond moving this state toward a more energy independent future, a successful bioeconomy should produce the following tangible benefits:

Strengthen existing industries: A successful bioeconomy will take advantage of and build upon Wisconsin's existing resources and industries, including those that produce primary and secondary feedstocks (agricultural, forestry, food and meat processing, municipal waste management, etc.), those involved in biomass processing (ethanol plants, digesters, co-firing plants, etc.), and those involved in manufacturing and distributing final products (manufacturing facilities, utilities, fuel distributors, etc.).

Generate new industries: A successful bioeconomy will create a market for bioenergy, biofuels, and bioproducts that draws new industry to the state to meet demand in these areas. New industry should especially focus on the processing and product development elements of the bioeconomy, as these are the value-added elements in the production chain.

Strengthen and develop links among industries: The bioeconomy depends on a range of industries that run the gamut from farming to manufacturing to education. A successful bioeconomy will depend on strong linkages among these industries, which span the most rural and the most urban parts of the state.

Generate private investment in new industries: The emerging biobased market will generate private capital investment in new ventures, especially in research and development of new, better technologies to convert biomass into viable products.

Create high-quality jobs: In strengthening existing industries, generating new industries, and generating capital investment, the bioeconomy will create jobs at every level of the production chain: research and development, biomass production, biomass processing, and product development and sales. Job creation will extend out to support industries such as transportation, building construction, and other industries related to the bioeconomy infrastructure, as well as to indirect industries like retail and the service sector. To be a truly successful economic development initiative, the bioeconomy must create high-quality, family-supporting jobs throughout Wisconsin, offering residents across the state a decent quality of life. Only by providing its residents with high quality jobs will the state build the stable tax base it needs to reinvest in the building blocks of the bioeconomy: physical infrastructure, education, and workforce training.

Generate wealth and provide ownership opportunities for rural communities: A successful bioeconomy must provide rural economies with more than the basic cost of the feedstocks harvested from their lands. It must provide rural landowners with opportunities to add value to these feedstocks through a variety of processing technologies, as well as some share of the resulting energy, fuel, and products.

Increase trade with other states and countries: Wisconsin's bioeconomy will be successful if it satisfies in-state energy, fuel, and product demands alone. However, an even more impressive model would produce products and technologies that the state can export to other states and countries.

Improve the environment: Because the bioeconomy has its roots literally in the land, a successful bioeconomy must ensure that the land is productive for generations to come. Thus a successful bioeconomy must balance raw material demand with long-term land preservation – including preservation and protection of the wildlife, water, and air that work together to support and enhance that land.

With these benefits in mind, we now turn to a discussion of biobased economy efforts in other countries and states, including the policies and incentives that have spurred some of those efforts.

POLICY/POLITICAL CONTEXT: INTERNATIONAL, FEDERAL AND STATE TAX POLICIES/INCENTIVES AFFECTING BIOINDUSTRY

International Policies and Incentives

In this section, we provide an overview of bioindustry programs taking place in other countries. This is by no means an exhaustive list; it is merely meant to give a broad picture of the global bioindustry market, so that Wisconsin can begin to imagine its potential place within that market. One key point does emerge from even this cursory overview, however, and it is that across the globe, governments are using specific policies and incentives to proactively encourage bioindustry development.

Snapshot of Bioenergy, Biofuels, and Bioproducts Around the World

Bioenergy: Biomass is the oldest energy source known to humanity, and it still plays a crucial role in the world's energy use, accounting for more than 10 percent of all global energy consumption (see **Figure 1**). However, many observers have pointed out the importance of distinguishing between developing and industrialized countries when talking about biomass. In developing countries, biomass – used primarily at the household level, for cooking and heating – accounts for between 30-40 percent of total energy consumption, and in some countries (mostly in Africa) consumption is as high as 90 percent. In industrialized countries, biomass accounts for only 3-4 percent of total energy consumption. Here, biomass is primarily co-fired in existing plants to produce electricity and heat, or used as a fuel in municipal heating facilities.[27]

Over the past few decades, both developing and industrialized countries have seen the potential to use biomass to create energy in a more efficient and environmentally friendly way, rather than simply burning raw materials to produce electricity and heat. To reduce the environmental and health effects from smoky wood fires, for instance, some developing countries have invested heavily in anaerobic digesters that can turn food and crop waste and animal waste into biogas. Community-owned digesters provide energy efficiently to decentralized rural areas, and provide important side benefits such as odor reduction and waste management. Moreover, digesters do not only create energy; they also produce high-quality fertilizer.[28]

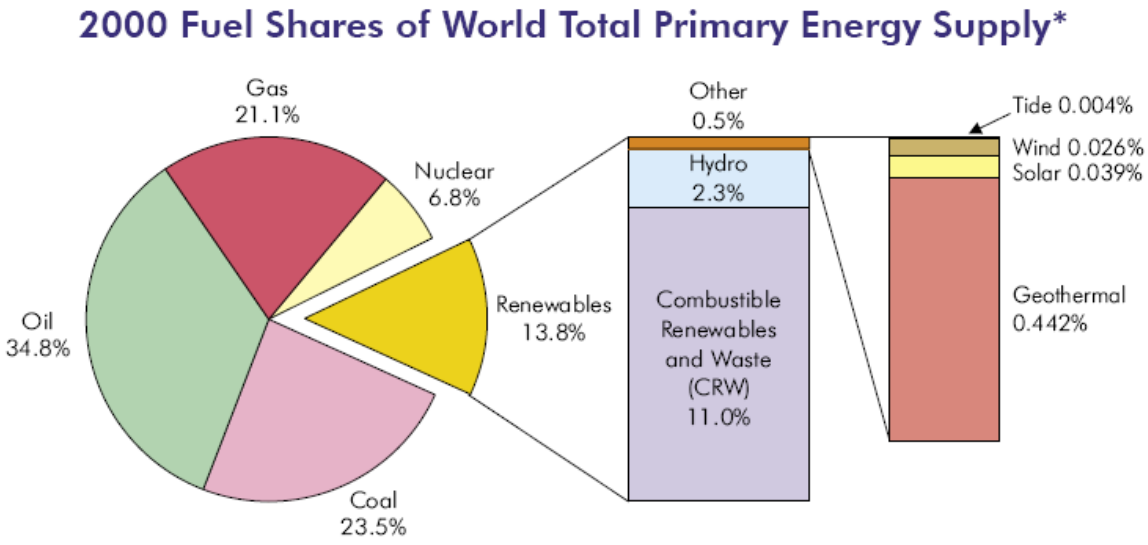
Examples of successful national biogas programs include India, where the government invested time and money into developing a low-cost polyethylene tubular digester, and now provides rebates to everyone in the country who installs one of these. By 2000, more than 2 million household-scale (average volume 10 m^3) biogas plants had been built in India, and the industry had created over 200,000 jobs.[29] Similar programs have been implemented in Nepal, Sri Lanka, and Vietnam. These countries, most dramatically Nepal, can now sell their carbon credits to

[27] IEA Bioenergy, Educational Site on Biomass and Bioenergy, available at http://www.aboutbioenergy.info (last visited July 3, 2005).
[28] Ho, Mae-Wan, *Biogas Bonanza for Third World Development*, Institute of Science in Society (June 20, 2005), available at http://www.i-sis.org.uk/BiogasBonanza.php
[29] Karottki, Rene and Gunnar Boye Olesen, *Biogass in India: A Sustainable Energy Success Story*, INFORSE (1997), available at http://www.ecouncil.ac.cr/rio/focus/report/english/inforse.htm.

richer countries that produce more greenhouse gases than allowed under the Kyoto Protocol; these payments are then reinvested into the poorer country's biogas program.[30]

In Europe, several countries have invested in new technologies in biomass energy. Examples include the Camphill digestion plant in Ireland, which meets the heat and power requirements of 90 people living in the community. This project, like the biogas digesters in India, was financed by the national government. Another, much larger-scale project is the Fibrowatt poultry-litter combustion power plant in the Thetford section of London, UK. The plant has an output of 38.5 megawatts (MW) of electricity, and consumes around 400,000 tons of poultry litter per year. This plant was mainly privately financed through international banks, and partially subsidized by the government. Finally, in Oslo, Norway, the new international airport is heated entirely by combustion of biomass (mostly wood waste), using an on-site plant. The project was financed through a combination of consumer fees and loans. [31]

Figure 1: 2000 Fuel Shares of World Total Primary Energy Supply



* TPES is calculated using the IEA conventions (physical energy content methodology). It includes international marine bunkers and excludes electricity/heat trade. The figures include both commercial and non-commercial energy; this explains the small differences with the figures presented in the *World Energy Outlook 2002 Edition* (WEO) where non-commercial biomass in Non-OECD countries is treated separately. The chapter of the WEO on Energy and Poverty as well as tables at the end of the book include non-commercial energy together with commercial energy sources.

Source: IEA Energy Statistics

[30] The Kyoto Protocol has created opportunities for digester construction by private interests such as AgCert, Inc. (www.agcert.com), which go into signatory developing countries and build a digester on livestock operations at no charge to the farm owner. The sale of carbon credits from the project to other Kyoto signatory countries pays for the digester. See Section 2, *infra*, for more information on the Kyoto protocol.

[31] For more information on these projects and others, *see* IEA Bioenergy's educational website on biomass and bioenergy, *supra* note 27.

Biofuels: The other area where biomass has been extensively explored by the international community is in the replacement of traditional transportation fuels such as oil and gas with biofuels. Biofuels that are in current production fall into two broad categories: ethanol (sugar-based or cellulosic) and biodiesel. Biofuel production is rising throughout the world, due in large part to the rising cost of fossil-based fuels (discussed in more detail in the next section). The possibility also exists to produce other liquid biofuels using processes such as biomass gasification to produce syngas, which is then transformed using Fischer-Tropsch processes to produce a syndiesel. Unlike ethanol and biodiesel, however, these processes have yet to be commercially demonstrated.

Ethanol: Brazil leads the world ethanol market:[32] Brazil produced nearly 37 percent (4 billion gallons) of the world's ethanol market in 2004, and 40 percent of all fuel pumped into cars in that country is ethanol, produced mainly from sugar cane.[33] The prevalence of ethanol in Brazil is due in large part to a government policy requiring that 25 percent of all gasoline sold in the country be ethanol; the resulting boom in the ethanol market has spurred large car companies like Volkswagen to begin producing flex-fuel cars that can burn up to 100 percent ethanol, and has channeled billions of private dollars into sugar and alcohol production in the Brazilian countryside.[34] Brazil's ethanol market was jump-started by government incentives: the national government subsidized early sugar production and the development of the first ethanol distilleries in Brazil in the 1970s and early 1980s. Its impacts are dramatic: besides moving Brazil away from dependence on foreign fuel and providing that country with a strong ethanol export market, the switch to ethanol has brought down the levels of lead, sulfer, hydrocarbons, and carbon monoxide emission in the country (though nitrogen oxide emissions, or NOx, have remained about the same). [35]

The U.S. is the second largest ethanol producer in the world, supplying about 33 percent (3.5 billion gallons) of the world ethanol market; however, ethanol accounts for only about 10 percent of all gasoline sales in the U.S. Currently, about 11 percent of the U.S. corn harvest is put into ethanol production. Ethanol is subsidized in the U.S. as it is in many countries: the federal government provides a 51 cent tax credit for every gallon of ethanol, and some states add extra credits. The U.S. also included a Renewable Fuel Standard in the 2005 Energy Bill (more on this below), and some states have imposed their own standards – for instance, New York and Connecticut require a 10 percent blend of ethanol and gasoline.[36] Currently, two million flex fuel cars capable of burning E85 (a bend of 85 percent ethanol and 15 percent gasoline) are sold in the U.S. each year; however, many purchasers are not aware that their cars can burn ethanol.[37]

Other countries are behind Brazil and the U.S. in ethanol production, but are catching up. China currently supplies only about 9 percent of the world market but has just built the world's largest ethanol plant and is planning another, and Canada is preparing to build the first full-scale

[32] Earth Policy Institute, *World Ethanol Production, 2004* (chart), available at http://earth-policy.org/Updates/2005/Update49_data.htm (last visited July 3, 2005).
[33] Dickerson, Marla, *Homegrown Fuel Supply Helps Brazil Breathe Easy*, L.A. Times, June 15, 2005.
[34] *Id.*
[35] Geller, Howard, Energy Revolution: Policies for a Sustainable Future (2003).
[36] Institute for Agriculture and Trade Policy (IATP), *CAFTA's Impact on U.S. Ethanol Market* (2005).
[37] Goldberg, Maren, *The Rise of E85*, Motor Age, Dec. 2004.

cellulosic ethanol plant, which would replace sugar-based feedstocks with straw.[38] Many countries are considering transitioning to cellulosic-based ethanol, which is potentially a much more efficient way to produce ethanol than corn- or sugar-based ethanol, especially if switchgrass or other so-called "energy crops" can be used as the primary feedstock.[39] Switchgrass is an attractive crop for both farmers and environmentalists, because it is fast-growing and perennial, needs little tilling and thus keeps higher levels of carbon in the ground than corn, needs far less irrigation than corn, and provides habitat for a number of wildlife species. Furthermore, it already grows wild on prairies and marginal crop lands across many parts of North America, including Wisconsin. Another potential ethanol feedstock, also attractive to farmers, is crop residue such as corn stover and wheat straw; woody biomass from forest residues is also a potential future ethanol feedstock.

Biodiesel: In most of Europe, where diesel cars are the norm, biodiesel production – primarily from rapeseed, sunflower, soybean and palm oil – is far more common than ethanol production. The EU produces 80 percent of the world's biodiesel, with Germany as the largest producer within the EU. The rest of the EU, notably France and Italy, are not far behind. Each of these countries provides some sort of tax incentive for biodiesel production.[40] A non-binding directive by the European Commission asks EU countries to meet 2 percent of vehicle fuel demand with biofuels by the end of 2005 and 5.75 percent by 2010; most observers believe this directive will be met primarily through biodiesel given the large number of diesel cars in Europe. Furthermore, biodiesel can be produced entirely in the EU, whereas ethanol production would still rely on imported gasoline to produce a useable fuel.

In contrast to Europe, the U.S. has been slow to adopt biodiesel technology, but production will almost certainly be spurred by the fact that the 2004 JOBS Act created a one cent tax credit for every 1 percent of biodiesel in the diesel mix. In providing this incentive, the U.S. is mirroring the EU, where biodiesel is often exempt from the gas tax. The U.S. company Cargill announced in June 2005 that it plans to build a 37.5 million gallon/year biodiesel plant in Iowa Falls, Iowa – this will be the largest biodiesel plant in the U.S. In addition, several U.S. states are exploring Renewable Fuel Standards that require a percent of all diesel fuel to be biodiesel.

[38] *Stirrings in the Corn Fields*, The Economist, May 12, 2005.
[39] Murray, Danielle, *Ethanol's Potential: Looking Beyond Corn*, Earth Policy Institute (June 29, 2005).
[40] USDA, EU: Biodiesel Industry Expanding Use of Oilseeds (September 2003), available at http://www.fas.usda.gov/pecad2/highlights/2003/09/biodiesel3/.

Figure 2: Ethanol Output, U.S. and Brazil/ Biodisel Output, EU

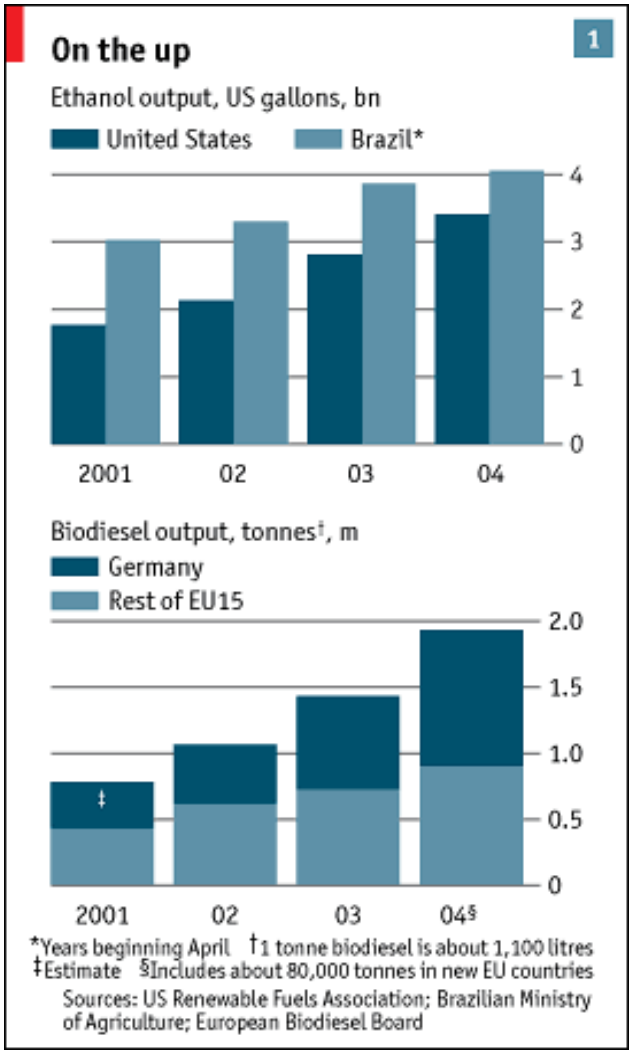


Chart Source: "Stirrings in the Corn Fields," The Economist, May 12, 2005.

Bioproducts: The third large potential market for biomass is in products that are currently petroleum-based, including many chemicals and plastics. Though not a new field (the "chemurgy" movement took off in the 1920s[41]), bioproduct development has progressed in fits and starts over the past century and is in some ways the least mature of the three bioindustry sectors. Moreover, much of this work is being done at private companies that are not willing to share information. However, several countries are pursuing industry partnerships, involving government, academia, and the private sector, to further explore bioproducts potential. One such partnership is BioProducts Canada, a non-profit, industry-led coalition focused on identifying Canada's potential to develop a strong bioproducts market. Their goal is that by 2010, Canada will be producing chemicals and polymers at internationally competitive prices, will attract a major bioplastic manufacturer to Canada, will create several agri-fiber production facilities, and

[41] Finlay, Mark R., *Old Efforts at New Uses: A Brief History of Chemurgy and the American Search for Biobased Materials*, Journal of Industrial Ecology, v. 7 n. 3-4 (Summer/Fall 2003), available at http://mitpress.mit.edu/journals/JIEC/v7n3-4/jiec_7_3-4_33_0.pdf.

will convince local aeronautics/automotive firms to use flax and hemp instead of glass fibers in some products.[42]

Similarly, Australia has convened a coalition of government, private industry and research institutions to "develop commercial applications of new bioproducts and bioprocesses." As with the Canadian group, the Australians are currently at the research, rather than the commercialization, phase for most of their technology, though they have developed several products such as pectin made from orange peels.[43] Australia's program differs from Canada's in that while Canada is focused on private industry grants, Australia focuses more on academia, by providing postgraduate opportunities and scholarships for researchers.

The U.S. is on the bioproducts train as well, as we discuss below. The USDA has developed several programs to promote bioproducts research, and recently released a set of guidelines for a federal procurement program requiring federal agencies to purchase biobased products. Most recently, the U.S. Department of Energy released a list of top value-added chemicals from biomass, which is serving as a roadmap for researchers in this field throughout the country.[44]

Other International Policies Affecting Bioindustry

Besides the national policies mentioned above, the worldwide bioindustry market is affected by several international treaties and obligations. The most important international treaty affecting renewable energy and fuel programs is the **Kyoto Protocol** on emissions and the environment, ratified by 70 countries (though not the U.S.). Kyoto requires that countries reduce their emissions of six key greenhouse gases by 5 percent by 2012, and therefore creates a market for low-emission technologies such as renewable energy and some biofuels.[45] Kyoto creates an open trading market for emission credits, allowing poorer countries that already use high levels of biogas and biofuels to receive payments for these projects from richer countries. In 2005, the average price paid per metric ton of CO_2 on the emissions market was between $4.23 and $5.63, depending on whether the emissions credit was certified by an official government entity or verified by an independent entity. By far the largest seller of Kyoto emission reduction credits is India, followed by Brazil and Chile. Kyoto also sets up specific benchmarks for all signatories, such as requiring that 2 percent of all fuel be biofuel by the year 2005, and 5.75 percent by 2010.

Two other international treaties are also important to discuss here, though their impact on the bioeconomy is more speculative than that of the Kyoto Protocol. The **World Trade Organization (WTO)** is the world body that administers the General Agreement on Tariffs and Trade (GATT), a multilateral trade agreement signed by 150 countries in 1947. The WTO is important to bioeconomy development because it regulates member country subsidies, including some subsidies for agricultural production. It is an open question whether subsidies to biomass growers and producers are classified as "industrial" subsidies, which are fairly restricted by the WTO, or whether these fall under the less restrictive WTO Agreement on Agriculture's "colored

[42] For more information on BioProducts Canada, see http://www.bio-productscanada.org/.
[43] For more information on CRC Bioproducts, see http://www.bioproducts.org.au.
[44] National Renewable Energy Laboratory, *Top Value Added Chemicals from Biomass Vol. 1: Results of Screening for Potential Candidates from Sugars and Synthesis Gases*, available at http://www.eere.energy.gov/biomass/pdfs/35523.pdf (August 2004).
[45] Europa, *The Kyoto Protocol – A Brief Summary*, available at http://europa.eu.int/comm/environment/climat/kyoto.htm (last updated January 26, 2005).

box system." Under this system, "Green Box" subsidies include environmental programs and are considered "non trade-distorting support," meaning that nations may have any number of these subsidies. There is some question whether bioindustry subsidies may be placed in the Green Box: under the Uruguay Round, programs placed in this box must be shown to be part of a clearly defined conservation or environmental program. More likely, bioindustry subsidies would fall into one of the boxes for trade-distorting subsidies: the "Amber Box," where subsidies are on a quota system such that each country has a set amount of money it can put toward these subsidies, or the "Blue Box," a more restrictive category also known as the "Amber Box with conditions."[46]

The WTO member countries are currently engaged in a new round of negotiations on agriculture, known as the **"Doha Round."** These negotiations are aimed at clarifying the colored box system for agricultural subsidies, and at limiting the number of subsidies that qualify for unregulated "Green Box" status. Specifically, the goals of the Doha Round include "substantial improvements in [agricultural] market access; reductions of, with a view to phasing out, all forms of export subsidies; and substantial reductions in trade-distorting domestic support."[47] Because these negotiations may result in the ultimate phase-out of most export and domestic agricultural subsidies, they will have an enormous impact on the feedstock growers who are at the very beginning of the bioeconomy production chain. However, as earlier stated, it is still an open question whether subsidies to producers such as ethanol and biodiesel plants will fall into the agricultural category or the industrial category.

The U.S. Congress recently ratified another potentially important agricultural trade agreement, the **Central American Free Trade Act (CAFTA)**. CAFTA opens up trade markets between the U.S. and six Central American countries: Costa Rica, Guatemala, El Salvador, Honduras, Nicaragua, and the Dominican Republic. The agreement is important to bioindustry development primarily because of its anticipated effect on ethanol production in participating countries. As the Institute for Agriculture and Trade Policy (IATP) points out in a recent paper, CAFTA will remove the 54 cent/gallon tariff currently placed on ethanol imports to the U.S., "lock[ing] in tariff-free access to the U.S. market for foreign ethanol."[48] Under the pre-CAFTA Caribbean Basin Initiative (CBI), 27 Central American and Caribbean countries may export ethanol duty-free to the U.S. up to 7 percent of all U.S. ethanol production. CAFTA makes this rule permanent for the CAFTA countries, many of which are low-cost sugar producers. The lure of this export market has already drawn many American agribusiness companies to open ethanol plants in Central America.

Both the WTO Doha Round and CAFTA are likely to affect the ability of member nations to subsidize and support crops related to the bioeconomy. Because subsidies have been an important part of Wisconsin's agricultural economy – and of the emerging bioeconomies throughout the rest of the developed world – these international discussions will almost surely play into this state's bioeconomy future. More certain is the fact that the Kyoto Protocol has enormous potential to open up new global markets for greenhouse gas-reducing bioenergy and biofuels – especially if the U.S. eventually signs onto Kyoto.

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[46] Loppacher, Laura J. and William A. Kerr, *Can Biofuels Become a Global Industry?: Government Policies and Trade Constraints*, Energy Politics (2005).
[47] Doha Wto Ministerial 2001: Ministerial Declaration (Sept. 20, 2001), available at www.wto.org.
[48] IATP, *supra* note 36.

U.S. Policies and Incentives Affecting Bioindustry

As is clear from the international examples given above, federal governments can heavily influence a country's bioeconomy by providing economic stimulus to the feedstock growers, processors, and sellers. The U.S. is no exception – when the U.S. government decides to go in a particular direction on bioeconomy development, massive amounts of federal financial and research support flow in that direction.

In the U.S., two large federal bills clearly affect this country's bioindustry potential: the Farm Bill and the Energy Bill. The U.S. also has many incentive programs, some authorized under one or the other of these bills, to encourage specific research and development of bioenergy, biofuels, and bioproduct technologies. This section attempts to highlight the most important bills and programs.

Farm Bill: The most recent Farm Bill, passed in 2002, contains a mix of procurement standards, grants, loan guarantees and education programs that work together to encourage bioenergy and biofuel production[49]:

- Section 9002 requires federal agencies to give procurement preferences to biobased products, when the item price exceeds $10,000. One of the stated purposes for this rule is to develop national energy security. This program is funded at $1 million/year.[50]
- Section 9003 establishes a grant program for the development of commercially viable biorefineries. Grants are awarded on a competitive bid basis, and grantees are required to contribute 70 percent of the cost.
- Section 9004 establishes a biodiesel education program, intended for nonprofits and educational institutions only. Under the program, grantees are funded to design educational outreach to public and private organizations that operate large vehicle fleets. The program is funded at $1 million annually through 2007.
- Section 9005 establishes a grant program for agricultural energy audits, with the goal of identifying opportunities for renewable energy and energy efficiency. Funding is not awarded to the farmer or rural community; rather, funding is provided to the state agency, nonprofit, university, rural electric cooperative or tribal authority responsible for conducting the audit. Funding for this program is available as necessary.
- Section 9006 establishes a grant, loan and loan guarantee program for renewable energy and energy efficiency systems. Through 2007, $23 million in grants is available annually.[51]
- Section 9010 subsidizes a portion of the feedstock cost for biodiesel and ethanol producers. A producer that refines less than 65 million gallons of biodiesel or ethanol will be reimbursed 1 feedstock unit for each 2.5 feedstock units. Refiners that produce over 65 million gallons will be reimbursed 1 feedstock unit for every 3.5 feedstock units. This program is funded at $150 million/year through 2006.

[49] Farm Bill provisions are available on line at http://www.ers.usda.gov/Features/farmbill/.
[50] Federal Biobased Products Preferred Procurement Program, *Farm Security and Rural Investment Act of 2002 (FSRIA) Launches New Biobased Products Initiative*, available at http://www.biobased.oce.usda.gov/public/index.cfm?CFID=31571&CFTOKEN=73 (last visited July 3, 2005).
[51] More information on Section 9006 is available at http://www.rurdev.usda.gov/rbs/farmbill/index.html.

- Conservation Reserve Program: The 2002 Farm Bill also made changes to the Conservation Reserve Program (CRP), the largest of the USDA's land conservation programs. This program provides rental payments to farmers to keep "marginal and highly erodable" land out of production, in order to improve soil and water quality and to provide wildlife habitat. The Farm Bill changed this program to allow managed biomass production and harvesting on these lands, consistent with overall CRP goals and with a rental payment reduction in accordance with any economic benefit the farmer might receive from biomass sales. This change opens up a significant amount of land for potential biomass production.[52] (Note: as of May 2005, Wisconsin has over 621,000 acres in the CRP.[53])

Planning is currently underway for the 2006 Farm Bill, which is expected to contain a number of new provisions related to bioenergy and biofuels.

Energy Bill: President Bush signed new federal energy legislation into law on August 8th, 2005. This bill provides a number of important incentives/programs relevant to bioindustry in Wisconsin. However, it is important to remember that this bill is an authorization, not an appropriation, measure: that is, the bill authorizes agencies to spend a certain amount of money on particular programs, but does not actually allocate that money to those agency budgets (this is done through a separate appropriations process, scheduled for 2006). It is unlikely that the full amount authorized through the bill will actually be appropriated; however, the bill does provide guidance to the direction that the federal government is taking in regards to bioeconomy development, and lays the groundwork for at least some funding for targeted programs. Some of the more important programs include:[54]

- Title II, Sec. 210: Creates a $50 million annual grant program from 2006-2016, that will provide money to offset the cost of projects to develop or research opportunities to improve the use of, or add value to, biomass. Grants are limited to $20/ton of green biomass delivered, with a maximum value of $500,000.
- Title IX, Sec. 941: Increases the funding and duration of the Biomass Research and Development Act of 2000 from $54 million/year from 2002-2007, to $200 million/year from 2006-2015.
- Title IX, Sec. 942: Sets a goal of developing the capacity to produce 1 billion gallons of cellulosic ethanol annually by 2015. Instructs the Secretary of Energy to develop a production incentive for cellulosic ethanol once the U.S. reaches an annual production capacity of 100 million gallons. Total funding for the future incentives is set at $250 million.
- Title XII, Sec. 1251: Requires all utilities to make net metering available to its customers upon request within two years.

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[52] More information on the Conservation Reserve Program is available at http://www.fsa.usda.gov/dafp/cepd/crp.htm.

[53] USDA, *Conservation Reserve Program Monthly Summary – May 2005*, available at http://www.fsa.usda.gov/dafp/cepd/stats/May2005.pdf (last visited July 3, 2005).

[54] This information is taken directly from the conference version of the Energy Policy Act of 2005, from the title and sections noted in the text. The bill was accessed 8/10/05 on the Senate Energy and Natural Resources Committee's site, available at: http://energy.senate.gov/public/_files/ConferenceReport0.pdf.

- Title XII, Sec. 1254: Amends the Public Utility Regulatory Policy Act (PURPA) of 1978 to require that all utilities make interconnection services available to customers upon their request within two years. The interconnection standards are to be based upon the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547.
- Title XV, Sec. 1501: Establishes a renewable fuel standard that requires the consumption of 7.5 billion gallons of ethanol by 2012. In order to spur the development of cellulosic ethanol technology, each gallon of cellulosic ethanol counts as 2.5 gallons of traditional ethanol.

(Appendix A includes a full list of relevant Energy Bill provisions.)

Besides passing federal bills relating to biobased industry, the U.S. government exerts influence over the national bioeconomy through two agencies: the Department of Energy (DOE) and the U.S. Department of Agriculture (USDA). These two agencies have expressed a strong commitment to expanding the U.S. market for biomass fuels and products. In 2002, the Biomass Initiative, a joint project of the DOE and USDA, presented its "Vision for Bioenergy and Biobased Products in the United States," calling for policies to increase the use of biomass to 10 percent of transportation fuels, 5 percent of heat and/or electricity demand, and 18 percent of chemicals and materials used in the U.S. by 2020.[55]

The USDA coordinates biomass research through the **USDA Biobased Products and Bioenergy Coordination Council (BBCC).** The BBCC, created by the Secretary of Agriculture, provides a forum for all the USDA agencies involved in bioproducts and bioenergy programs to coordinate research, share information, and help market biobased technologies. The Council provides a clearinghouse of information about federal programs in these areas, including available grants for bioindustry projects.[56] BBCC also provides a forum for high-level agency involvement with other agencies' biobased efforts, including those of the DOE and EPA.

The BBCC administers the **Biomass Research and Development Act of 2000**, also known as Title III of the Agricultural Risk Protection Act of 2000. It provides $49 million in research and development funding, administered through the USDA and focused on the conversion of biomass into ethanol, polylactates, and electricity. This Act is significant in large part because it provides money for research into bioproducts like bio-based chemicals and polymers.

Another important DOE/USDA program currently underway is the **Federal Biobased Products Preferred Procurement Program (FB4P)**, which will eventually require federal agencies to purchase biobased products. The USDA is currently collecting product information in order to designate qualifying biobased products for this program.

Finally, a locally-based federal program is the **USDA Forest Products Laboratory (FPL)** in Madison, Wisconsin, which includes the State & Private Forestry Technology Marketing Unit. Its mission is to improve the use of wood by transferring technologies developed primarily by the FPL and other Forest Service research installations. To this end, the FPL works in collaboration with Forest Service Research and Development to identify opportunities for

[55] Report available at http://www.bioproducts-bioenergy.gov/pdfs/BioVision_03_Web.pdf.
[56] For more information on the BBCC, *see* http://www.ars.usda.gov/bbcc/.

working with local governments, private landowners, rural communities, and forest industries. The Lab also supports the national and international research mission of the Forest Service in forest products utilization by ensuring ready adoption of forest-based material technologies. Their scope of technology marketing work includes forest products conservation, processing, manufacturing efficiency, marketing, and recycling.[57]

Through its grant programs, tax incentives, loan guarantees and other policy initiatives, the federal government has an enormous influence on what types of technologies – and what feedstocks – will most likely be used to reach these goals.

Selected Bioindustry Efforts in the Midwest Region

Perhaps more important than the federal incentives available for bioindustry projects are the actual projects being pursued at the state level. In this section, we provide an overview of some of the projects – including state initiatives similar to the Governor's Biobased Consortium, as well as government-university-industry consortia focused on building the bioeconomy – taking place in other Midwestern states.

Midwestern region: The **Midwest Consortium for Sustainable Biobased Products and Bioenergy** was formed in response to a 1999 federal mandate to triple the use of biobased products and energy in the U.S. by 2010. The Consortium links four land-grant universities (Michigan State University, Iowa State, Purdue, and the University of Illinois) with two DOE labs (Argonne National Lab in Chicago and Ames Laboratory in Iowa) with a goal of developing a biobased economy roadmap. The Consortium is currently engaged in a research project focused on developing opportunities to further the use of distillers grains (DG) for production of alternative chemical and fuel products.

The Council of Great Lakes Governors has administered the **Great Lakes Biomass State-Regional Partnership (GLBSRP)** under contract with the U.S. Department of Energy (DOE) since 1983. This is one of five regional programs established by DOE and designed to encourage greater production and use of biomass for energy generation. Biomass includes wood, crop residues, municipal waste, and other organic materials that can be converted for power production and transportation fuels including ethanol and biodiesel. One position in Wisconsin's State Energy Office is funded in part through GLBSRP funds.

Dakotas: South Dakota State University is participating in another regional initiative, the **Sun Grant Initiative**, which also brings land-grant universities (South Dakota State, Oregon State, Oklahoma State, University of Tennessee-Knoxville, and Cornell University) together with DOE laboratories to explore bioindustry strategies. The Sun Grant Initiative is focused specifically on developing bioindustry strategies that will benefit farmers and rural communities.

Illinois: Governor Blagojevich recently signed into law a **biodiesel procurement measure** requiring government at all levels (state, local, school boards, county, etc.) to fuel diesel buses with 2 percent biodiesel. The state also provides rebates for consumers who use a biodiesel blend of 20 percent or more. Illinois is also the home of the **AgTech Initiative**, a partnership between

[57] More information on the Forest Products Lab can be found at http://www.fpl.fs.fed.us/tmu/about_us.html.

the City of Belvidere, Boone County, and the private sector that focuses on developing new uses (primarily bioproducts) for local farm commodities.

Indiana: In May 2005, Indiana unveiled a new strategy designed to encourage agribusinesses to manufacture ethanol and biodiesel fuel in the state, with a goal to turn the state into the "Texas of alternative fuels." The state's strategic plan for agriculture sets a goal of producing 100 million gallons of biodiesel and tripling ethanol production in the state by 2010. On the bioproducts side, Indiana's Purdue University is a member of the Midwest Consortium on Biobased Products and Bioenergy, and Purdue's Integrative Center for Biotechnology and Engineering is spearheading the Consortium's current effort to coordinate research on adding value to distiller's grains by using the grains in ethanol and bioproduct processes.[58]

Iowa: The state of Iowa has put significant resources toward bioindustry development, and has done so over a number of years. In June 2003, Governor Vilsack adopted the **Biobased Products and Bioenergy Vision and Roadmap for Iowa**. To implement this roadmap, the state formed the **Biowa Development Association**, a consortium of government, private industry and researchers. Biowa has three very aggressive goals: to develop at least ten regional biorefineries by 2020, that the state build at least five biobusinesses (or significantly expand existing biobusinesses) each year starting in 2005, and that the state provide investment opportunities in bioindustry for Iowans. Iowa State University is involved in Biowa but also has two separate bioindustry initiatives: **CIRAS**, a technology transfer organization that helps businesses and communities develop and market biobased technologies, and **Biorenew**, an interdepartmental graduate program in Biorenewable Resources and Technology designed to initiate engineering and science students into the use of plant- and crop-based resources in the production of bioenergy, biofuels, and bioproducts.

Michigan: Michigan State University is a member of the Midwest Biobased Consortium; the University also has two other bioindustry projects: the **Center for Plant Products and Technology**, a research center that provides initial funding for new and innovative plant-based technologies (and for capital equipment associated with these technologies), and **SINAS**, the Starch Institute for Non-Traditional Applications of Starch, where researchers are working on biochemical and genetic modification of starch for the production of plastics.

Minnesota: The **Minnesota Center for Biorefining**, located at the University of Minnesota, is the locus for a network of researchers, government officials, and private industry actors interested in the development of biorefining technologies. As the name suggests, the Center is focused mostly on bioproduct development. The University has also renamed its Department of Wood and Paper Science; the department is now the Department of Bio-based Products, offering "broad-based training focusing on the fundamentals and applications of bio-based products." On the biofuels side, Minnesota is far ahead of the rest of the country, having just passed a **Renewable Fuels Standard** requiring that all fuel sold in the state contain 20 percent ethanol by 2013.

[58] More information on this project is available at the Center's website, http://fairway.ecn.purdue.edu/~lorre/16/research/consortium.shtml.

Wisconsin Policies and Initiatives Affecting Bioindustry

In addition to its potential to use the federal incentives discussed above, Wisconsin has a number of state-level policies and initiatives designed to foster bioindustry and other renewable energy/fuel programs. These programs are administered by several different agencies. The Department of Agriculture, Trade and Consumer Protection generally administers policies related to agriculture and food production. The Department of Natural Resources, Division of Forestry generally oversees forestry programs in the state. The Department of Administration, Division of Energy oversees renewable energy policy, and is the contract supervisor for the Focus on Energy program, which runs the state's Public Benefits Fund (described below). The Department of Revenue oversees tax incentives and credits for various programs related to bioindustry and renewables. And the Department of Workforce Development and Department of Commerce oversee all programs related to workforce and economic development in the state – programs that represent a crucial piece of the bioindustry development puzzle.

Following are some of the more specific policies and incentives related to Wisconsin's bioindustry potential.

Policies

Renewable Portfolio Standard (RPS): The RPS is one of the most important ways that a state or country can create a predictable market for renewable energy, because it sets long-term (multi-year) requirements on the amount of electricity that must be produced by renewable sources. Wisconsin law currently requires that by the end of 2011, 2.2 percent of Wisconsin's energy must come from renewable sources. The law includes a credit trading program that enables electric service providers to sell renewable credits to other electric providers for any renewable energy excess. (The Governor's Task Force on Energy Efficiency and Renewables recommended increasing the RPS to 10 percent by 2015 – see below for more details.)

Public Benefits Fund: Wisconsin's Public Benefits fund is supported by fees added to consumer electric bills, as well as by investor-owned utilities, participating municipal utilities and electric cooperatives, federal funds, and voluntary contributions. The fund supports both the Focus on Energy program and the Home Energy Assistance program and is administered by the Department of Administration. Between FY2001 and FY2005, the Public Benefits Fund spent over $162 million on energy efficiency programs, and about $8 million on renewable energy programs. The state's FY2006 budget allocates about $37.5 million in new funds for energy efficiency programs, and about $2 million in new funds for renewable energy programs.[59] One of Focus on Energy's primary goals for the past several years has been to encourage bioenergy at large dairy farms; another has been to support biomass heating at small businesses and institutions.[60]

[59] Data from Cheryl Rezabek, WI Dept. of Administration.

[60] Database of State Incentives for Renewable Energy (DSIRE), *Wisconsin Incentives for Renewable Energy*, available at http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=WI02R&state=WI&CurrentPageID=1 (last updated August 3, 2004).

Interconnection/Net Metering: Interconnection standards provide a framework for small, remote power generators (such as digesters) to be connected to the electricity grid. They are a crucial piece of the bioenergy puzzle, especially in a state with many smaller farms and forestry operations. Wisconsin's interconnection standards, which went into effect in 2004, cover all distributed generation facilities 15 MW and below.[61]

Tax Credits for Agriculture and Forestry:[62] One basic way that Wisconsin encourages the bioindustry sector is by supporting its farm and forestry sectors, which produce the vast majority of the raw materials needed for any bioenergy, biofuels, or bioproducts project. For example, the Wisconsin Department of Revenue provides tax relief (amounting to approximately $29 million in direct benefits in 2001) for farmers through the Farmland Preservation Credit and the Farmland Tax Credit.[63] Through the state's Department of Natural Resources, Wisconsin provides tax relief for foresters via the Forest Crop Law and the Managed Forest Law.[64]

Ethanol Subsidies: Wisconsin currently offers a 20 cent/gallon production incentive to in-state ethanol producers through Wisconsin Act 55, signed in 2000. Producers may take the subsidy on the first 15 million gallons produced; they must produce at least 10 million gallons per year to qualify for the program.[65] Unless it is renewed, this program will expire on June 30, 2006.

Alternative Fuels: Wisconsin encourages the use of alternative vehicle fuels in several different ways. The Department of Revenue offers a state alternative fuel vehicle (AFV) tax deduction that is identical to the federal AFV tax deduction. (The full deduction is $50,000 for any truck or van with a gross vehicle weight rating (GVWR) of at least 26,000 lbs. or a bus with seating capacity of at least 20 adults. The deduction is $5,000 for a truck or van with a GVWR greater than 10,000 lbs. and $2,000 for vehicles under 10,000 lbs.) Beginning in 2002, the deduction amount has been decreasing each year; the program ends in 2007. The Department of Administration requires that state employees use hybrid gas/electric technologies or other alternative-fuel methods on state-owned or state-leased vehicles whenever possible.[66]

Clean Fuel Fleet Program (DNR): This program affects the six-county (Milwaukee, Waukesha, Ozaukee, Washington, Racine, and Kenosha) severe ozone non-attainment area. Under the program all public and private fleets with 10+ vehicles below 26,000 pounds, that

[61] Wisconsin Interconnection Collaborative, *Wisconsin Distributed Generation Interconnection Guidelines* (April 9, 2004), available at http://www.wisconsindr.org/WI_InterconnectionGuidelines.pdf.
[62] The Legislative Council recently produced a Briefing Book on agriculture for Wisconsin legislators, which has a far more comprehensive list of all the policies and incentives provided to Wisconsin agricultural interests. The book is available online at http://www.legis.state.wi.us/lc/2_PUBLICATIONS/Briefing%20Book%202004/Agriculture/agriculture.pdf.
[63] Wisconsin Department of Revenue Division of Research and Policy, *Farmland Preservation Credit Program and Farmland Tax Relief Credit Program* (January 29, 2002), available at http://www.dor.state.wi.us/ra/frm2002.html.
[64] Wisconsin Department of Natural Resources, *Wisconsin's Forest Tax Laws* (April 29, 2005), available at http://www.dnr.state.wi.us/org/land/forestry/ftax/index.htm.
[65] 1999 Wisconsin Act 55.
[66] Wisconsin Statutes 16.045

are able to be centrally fueled, must be 70 percent compliant (for vehicles below 8,500 lbs.) and 50 percent compliant (for vehicles between 26,000 and 85,000 lbs.). Compliance is reached by acquiring clean vehicles, converting vehicles to clean vehicles, or redeeming tradable credits. One of the goals of the program is to start to combat the dominance of gasoline as a fuel for cars; the program therefore creates a market for renewable fuels such as ethanol and biodiesel.[67]

Initiatives:

Governor's Task Force on Energy Efficiency & Renewables: In fall of 2003, Governor Doyle announced an initiative to create a task force focusing on restoring Wisconsin's position as a leader in energy efficiency and renewable energy resources. The task force, consisting of experienced leaders from the energy sector, released its final report in 2004.[68]

- The Report encouraged the state to adopt a RPS of 10 percent statewide renewable energy use by 2015. For state agencies, the standard would be 10 percent renewable energy purchase by 2006, and 20 percent by 2010. This would be a dramatic increase from the current RPS requirements, and would bring Wisconsin more in line with states such as Illinois (RPS requires 5 percent by 2010; 15 percent by 2020).
- On biomass specifically, the Report encouraged DATCP to establish a new position of Bioenergy/Biofuel Coordinator. It also supported increasing funding for two projects to encourage research and development into anaerobic digesters: the Agricultural Development and Diversification (ADD) Grant Program, which awards grants on a competitive basis to new technologies, research and development projects, and feasibility studies for farmland resources; and the Wisconsin Agricultural Stewardship Initiative (WASI), a non-profit organization established to coordinate and guide the application of technologies developed on DATCP pilot farms.

Governor's Biofuels Initiative: On January 15, 2005, Governor Doyle announced a goal to reduce Wisconsin's dependence on foreign oil while enhancing the state's agricultural market. As part of this goal, the most recent state budget includes $1 million in grants for Wisconsin farmers who produce feedstocks for bioenergy. The Governor also created a Consortium on Biobased Industry to devise a plan on how to best promote the development of biobased products and energy.[69] Governor Doyle's Biofuels Initiative also includes this analysis of Wisconsin's competitive position in the biobased sector relative to other states, the U.S., and the world.

DATCP's Working Lands Initiative: DATCP very recently created a Working Lands Initiative to consider policies and practices affecting agricultural and forest land preservation in the state, including policies related to bioindustry. The Initiative, which had its first

[67] Wisconsin Department of Natural Resources, *Clean Fuel Fleet Program – General Information* (October 8, 2004), available at http://dnr.wi.gov/org/aw/air/reg/cff/cff.htm.
[68] The full Report of the Governor's Task Force on Energy Efficiency & Renewables (October 2004) is available at http://energytaskforce.wi.gov/docview.asp?docid=76.
[69] The Governor's press release announcing the Consortium members, complete with a list of those members, can be found at http://www.wisgov.state.wi.us/journal_media_detail.asp?prid=1186.

meeting on July 13, 2005, is primarily focused on preserving Wisconsin's most productive farmland, much of which is being lost to residential and commercial development, especially in the Madison-Milwaukee-Chicago triangle. Through the Initiative, DATCP hopes to address urban sprawl and farmland preservation issues in tandem, rather than as separate problems contemplated by separate agencies and policymakers.[70]

Wisconsin Council on Forestry: The Council was created in 2002 to advise the Governor, legislature, Department of Natural Resources, Department of Commerce, and other state agencies on issues affecting forests across the state. The Council recently came out with a Woody Biomass Task Force Report, recommending policies to encourage the state to effectively use woody biomass to meet energy and fuel needs.[71]

Wisconsin Clean Cities – Southeast Area: Wisconsin Clean Cities (WCC), part of the national Clean Cities network, is a public-private partnership dedicated to expanding renewable fuels and clean transportation options in the Milwaukee area. WCC's current projects include a partnership with the General Mitchell International Airport to help the Airport to integrate alternative fuels into its daily operations, and a project with the DOE and Utica Energy to expand the state's network of E85 fueling stations.

Other Bioindustry-Related Programs:

Wood Heating in Schools: In 2003, the Dept. of Administration/Division on Energy asked the Biomass Energy Resource Center (BERC) to help determine if the state should create a program to promote the use of wood heating in the state's schools. BERC concluded that: "Biomass heating in schools holds great promise to advance renewable energy policy, stabilize and reduce school heating costs, benefit the local economy, support the forest products industry, and reduce greenhouse gas emissions," and that "Much of the expertise needed to deliver a successful program already exists, in various state agencies and program partners."[72]

[70] For more information on the DATCP Working Lands Initiative, including committee members, see http://www.datcp.state.wi.us/workinglands/index.jsp.
[71] A summary of these recommendations can be found at http://wisconsinforestry.org/pdf/BiomassTaskReport.pdf.
[72] Biomass Energy Resource Center, *Feasibility Study: Wisconsin School Wood Energy Program* (2003), available at http://www.biomasscenter.org/reports/wisconsin-school-wood-energy-study.html.

WISCONSIN'S POTENTIAL PLACE IN THE BIOECONOMY

In this section, we move from the general overview of global bioeconomy development to more deeply explore Wisconsin's potential to build a bioeconomy. We address this potential in two ways: first, we examine the state's existing land, industrial, and human resources in order to determine whether Wisconsin is in a good position to take advantage of current, short-term, commercialized bioindustry technologies such as ethanol, biodiesel, biomass co-firing, and methane digesters.

Second, we look at the infrastructure that Wisconsin has already developed, or could develop, in order to support the future bioeconomy. No matter what that future brings, we know that it will depend on a well-trained workforce, solid transportation networks, and an educational system that is prepared to research and help commercialize emerging technologies. Moreover, we know that it will require a state government that has thought hard about the relationship between all the diverse stakeholders invested in the bioeconomy, including academia, industry, labor, agriculture, forestry, and government itself.

Our conclusion from this exploration of Wisconsin's current and future potential is that the state does indeed possess many of the ingredients necessary to jump on the bioeconomy wagon, including:

- Strong agricultural, forestry, and manufacturing sectors, which will provide the basis for the feedstock growing, collection, and processing functions of the bioeconomy;
- Local distinctiveness and regional competitiveness in a number of other industries that will be important to a diverse bioeconomy, including many of the potential end-users of biochemicals and other bioproducts;
- An internationally recognized university that can provide much of the basic research and development for the bioindustries of the future;
- A strong workforce development system that focuses on training the state's workers for current and emerging industries; and
- A multi-modal transportation system that includes highways, rail, and ports, all of which will be key to an economic system reliant on the efficient transport of biomass and biobased products.

However, many of these ingredients are in danger of going bad. The state's farms, forestry, and manufacturing sectors have been badly scarred by international trade pressures. Its workforce is well-educated up to the high school level, but many workers lack the college degrees they need to remain competitive in the new economy. The population as a whole is aging, meaning that retiring workers are not necessarily being replaced by younger residents. And while Wisconsin's bioindustry mix is strong, it is weaker in many areas than that in surrounding states, many of which (as we discussed above) are already fully organized and taking advantage of bioenergy potential.

For these reasons, we feel strongly that Wisconsin must act now, both to fully capitalize on its existing strengths and also to organize its industries, workforce, and stakeholders to take advantage of future opportunities for bioindustry development.

Why Should Wisconsin Promote the Bioeconomy?

Wisconsin's Existing Industries are Key to a Successful Bioeconomy

As we noted in the early part of this paper, one key indicator of a successful bioeconomy is that it strengthens existing industries. Wisconsin, with its mix of primary and secondary feedstock producers (farms and forests, food and meat processing), machine and small-parts manufacturing industries, and other support industries related to the bioindustry, has many of the building blocks necessary for a comprehensive bioeconomy. Moreover, as this section indicates, each of these sectors is currently in some level of decline, and therefore in need of the new investments and new market opportunities a bioeconomy might create in Wisconsin.

Agricultural Industry

Wisconsin's farms and forests – the source of the majority of the state's biomass – are critical to its bioindustry strategy, and the next two sections will discuss these industries in greater detail. Wisconsin has nearly 16 million acres of farmland, comprising about 45 percent of the state's entire land area. Of the land farmed in the state, 68 percentis used as cropland, 20 percent as woodland, about 5 percent as pasture, and about 7 percent for houses, ponds, roads, wasteland, etc. Of Wisconsin's total exports in 2003, 11 percent were agricultural products, including live animals and dairy products as well as cereals, soybeans, and meat products. The top five importers of these goods were Canada, Mexico, Korea, Japan, and China.

Wisconsin is notable in that while the rest of the country has seen the decline of the family farm, the average (mean) farm in this state is still a fairly small 204 acres. However, these data do not tell the whole story: while the average farm is fairly small, Wisconsin has seen growth in both larger farms (through consolidation) and much smaller, niche enterprises. Table 2 illustrates this trend, showing growth in the 1-99 acre and the 2000+ acre farm, and decline in farms in between.

Table 2: Wisconsin Farm Size, 1992 - 2002

	1992	1997	2002
Average farm size (acres)	228	204	204
Farms by size (percent)			
1 to 99 acres	32.0	40.7	46.4
100 to 499 acres	59.2	51.6	45.4
500 to 999 acres	7.1	5.8	5.8
1000 to 1,999 acres	1.5	1.5	1.8
2,000 or more acres	0.3	0.4	0.6
Source: Census of Agriculture			

Most Wisconsin farms (nearly 90 percent) are owned by a single family or proprietor rather than a corporation, and all or a large proportion of the farm labor is done by the farm household rather than by tenant farmers.[73] The average age of Wisconsin's principal farm operators is 53 years, up

[73] See University of Wisconsin Program on Agricultural Technology Studies, *Wisconsin Farm Research Summary* (March 2000), available at http://www.pats.wisc.edu/pdf%20documents/poll99.pdf.

from 50 years in 1992 – farmers, like the rest of the state's population, are aging. About 60 percent of these operators list farming as their primary occupation. That farming does not provide an adequate income for many working in the industry is not surprising, given data from the Bureau of Labor Statistics (see Table 3) showing that in May 2004, the mean annual income for those working in the farming, fishing, forestry operations was just $25,900. Within this industry, farmworkers are at the low end of the scale, earning less than $20,000 per year; supervisors and managers earn the highest incomes of the industry, nearly $40,000 per year. Given these incomes, it is clear that a major goal of Wisconsin's bioindustry strategy must be income and wealth generation for the state's farmers. Without these farmers and their land, any serious bioindustry plan for the state will certainly fail.

Table 3: Wisconsin Farm and Forestry Employment and Income, May 2004

Occupation Title	Employment (1)	Median Hourly	Mean Hourly	Mean Annual (2)	Mean RSE (3)
Farming, Fishing, and Forestry Occupations	4,170	$11.37	$12.45	$25,900	2.2 %
First-Line Supervisors/Managers of Farming, Fishing, and Forestry Workers	400	$19.14	$18.96	$39,430	3.3 %
Agricultural Inspectors	260	$17.05	$16.48	$34,290	2.0 %
Animal Breeders	290	$14.79	$17.30	$35,980	3.9 %
Graders and Sorters, Agricultural Products	440	$8.50	$9.79	$20,370	4.5 %
Agricultural Equipment Operators	210	$11.42	$12.57	$26,140	3.5 %
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	520	$8.31	$8.65	$17,990	3.7 %
Farmworkers, Farm and Ranch Animals	910	$9.99	$10.26	$21,340	2.3 %
Agricultural Workers, All Other	170	$10.23	$10.68	$22,200	4.9 %
Forest and Conservation Workers	180	$14.93	$14.32	$29,780	4.7 %
Fallers	(not released)	$11.64	$11.39	$23,680	5.8 %
Logging Equipment Operators	280	$12.26	$12.68	$26,370	3.2 %
Log Graders and Scalers	270	$11.23	$12.26	$25,490	10.6 %
Logging Workers, All Other	(not released)	$13.22	$14.01	$29,140	9.5 %

(1) Estimates for detailed occupations do not sum to the totals because the totals include occupations not shown separately. Estimates do not include self-employed workers.

(2) Annual wages have been calculated by multiplying the hourly mean wage by a "year-round, full-time" hours figure of 2,080 hours; for those occupations where there is not an hourly mean wage published, the annual wage has been directly calculated from the reported survey data.

(3) The relative standard error (RSE) is a measure of the reliability of a survey statistic. The smaller the relative standard error, the more precise the estimate.

Source: Bureau of Labor Statistics (BLS)

Forestry Industry

Wisconsin's wood and wood products industry will likely be the other major source of primary biomass as the state pursues bioindustry. Wisconsin boasts 16 million acres of forest land (46 percent of the state's entire land area), 70 percent of which is privately owned. Much of this land is used to support the wood and wood products industry, which includes logging operations,

sawmills and kilns. As of 1995, this industry provided Wisconsin with about 28,000 jobs, most paying from $25,000 - $39,000 per year (see Table 3). The pulp and paper industry, another important source for woody biomass, generates another 44,000 jobs in the state. Moreover, paper mill operators are some of the highest-paid manufacturing employees in the state, with wages up to $49,000 annually. Between logging activities, furniture and other wood product production, and paper, fully 1 in 6 of all manufacturing jobs in the state are directly related to the forest products industry.[74]

Wisconsin's forest products industry is comprised of a large number of relatively small firms – altogether, the state boasts over 1800 forest product companies. However, the number of firms has begun to decline as a result of consolidation and closure.[75] As in the manufacturing industry as a whole, the forest products industry has lost thousands of jobs since the 2001 recession. At least 15 medium-sized sawmills have closed in the past five years, and the number of logging contractors has steadily declined, mostly due to consolidation and global pressures. The pulp and paper industry lost 5,000 jobs from 2000-2004; the Paper Industry Council has attributed this loss to consolidation, globalization, and a lack of capital investment in the industry compared to neighboring states Minnesota and Michigan.[76] As is the case in the agricultural sector, it is clear that the forestry sector could benefit from the development of markets for biobased products and industry investment in biorefinery processes and technologies.

Manufacturing

Wisconsin's manufacturing infrastructure will be crucial to the state's ability to pursue a bioindustry plan. Processing biomass into bioenergy, bioproducts, and biofuels will require new processing plants and manufacturing facilities, as well as the small machine parts already being produced in the state. Non-durable goods manufacturers, such as those that make plastics or construction materials, may become key end users of biobased chemicals, acids, and adhesives. Finally, facilities like food processing plants and breweries currently create waste that can be productively used in bioindustry processes; these facilities may become a key source of biomass for the state's bioeconomy plan. Because this sector is central to the bioeconmy, and because it is historically such a strong sector in this state, it is worthwhile to give a brief overview of the long-term trends in Wisconsin manufacturing.

Between 1979 and 2000, the number of manufacturing jobs in the state increased by 4 percent. However, the 2001 recession decimated the manufacturing sector in the state. From March 2001 to January 2004, Wisconsin lost 75,000 manufacturing jobs – a decline of 14 percent in the overall manufacturing base. The sector saw some job gains during 2004, but the sector still remained nearly 10 percent smaller than it had been before the recession. This job loss is of central concern in Wisconsin. Our manufacturing sector remains a crucial part of the state's economy, and the source of some of its best-paying jobs, especially for the three-quarters of Wisconsin workers who lack college degrees. As we discuss further below, workers in the manufacturing sector (durable and non-durable) have much higher wages than retail and service workers, the other sectors where non-college-educated residents most often find jobs.

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[74] Center for Technology Transfer, *Wisconsin's Forest Products Industry - Business Climate Status Report 2004*, available at http://www.cttinc.org/BusinessClimateStatusRptRevised.pdf (last visited July 4, 2005).
[75] *Id.*
[76] Wisconsin Paper Council, *The State of Wisconsin's Paper Industry* (2003).

Measuring Wisconsin's Competitiveness in Biobased Industries: Location Quotients and GSP

Farms, basic forestry and paper operations, and manufacturing are not the only industries that will be affected by a bioindustry plan in Wisconsin. A host of diverse industries, from secondary feedstock producers like food processors, to support industries like machine part manufacturing and truck transport, will also be affected. In this section we examine Wisconsin's potential competitive advantage in a number of industries related to the bioeconomy, using two regional economic analysis tools: "location quotients" and Gross State Product.

Location Quotients: A location quotient is simply the ratio between a chosen economy (in this case Wisconsin) and a reference economy (in this case the U.S). Wherever Wisconsin's concentration of employees is greater in a particular industry than the concentration of employees in that industry in the U.S., the location quotient is above 1.0. Where Wisconsin's concentration is below that of the U.S., the location quotient is below 1.0. A location quotient above 1.0 indicates that it is more likely in Wisconsin than in the country as a whole that a person will work in a given industry; for instance, a location quotient of 6.0 means that someone in Wisconsin is six times as likely to work in that industry as in the U.S. Thus location quotients provide a fairly good measure of the state's local distinctiveness in particular industries, and also its potential for growth in those industries.[77]

Table 4: Wisconsin Top 20 Industries by Location Quotient

Sector	Description	WI Location Quotient
231	Kitchen utensil, pot, and pan manufacturing	23.6
254	Enameled iron and metal sanitary ware manufacturing	21.8
63	Creamery butter manufacturing	19.6
50	Malt manufacturing	19.1
320	Irradiation apparatus manufacturing	18.7
264	Paper industry machinery manufacturing	17.7
64	Cheese manufacturing	16.8
359	Motorcycle, bicycle, and parts manufacturing	14.0
286	Other engine equipment manufacturing	9.0
253	Industrial pattern manufacturing	7.4
125	Paper and paperboard mills	7.4
258	Lawn and garden equipment manufacturing	7.3
336	Relay and industrial control manufacturing	7.3
338	Primary battery manufacturing	7.2
164	Polish and other sanitation good manufacturing	7.2
327	Electric housewares and household fan manufacturing	6.8
117	Wood windows and door manufacturing	6.2
129	Coated and laminated paper and packaging materials	6.1
287	Speed changers and mechanical power transmissions	6.1

[77] This is of course a simplification, as demand varies regionally.

Wisconsin's top twenty industry LQs are listed in Table 4.[78] These data paint one picture of the state's strengths – for instance, they show that the state has local distinctiveness in manufacturing. However, they do not answer the more important question of whether the state will be competitive in the broad cross-section of industries that make up the bioeconomy. If Wisconsin is to have any competitive advantage in creating a bioeconomy, it must have local distinctiveness in the industries most related to the bioeconomy – industries directly related to growing bioindustry feedstocks, for instance – but also industries that will be involved in processing the biomass, turning it into end products, and using those end products. Other related industries include the educational sector, where most of the research and development for emerging bioprocesses will take place. Taken together, these interrelated industries might be seen as a bioeconomy "cluster."

In order to more fully explore Wisconsin's potential strength in this bioeconomy cluster, we identified those industries that we felt would have a significant role to play in that economy, and then sorted these by location quotient. Our industry classifications are as follows:

- "F" indicates an industry that might create biomass as its primary or secondary industry function – for instance, this category includes grain farmers, who produce biomass as a primary function, as well as breweries, which produce waste yeast and other secondary biomass products.
- "PROC" indicates any industry involved in processing or moving the final product (energy, fuel, or bioproducts).
- "PROD?" indicates industries that might be involved in turning biomass into various plastic, chemical, or other products – the question mark indicates the fact that these classifications are largely speculative, due to general lack of mature research in the bioproducts field.

Table 5 shows the state's top forty biobased industries, sorted by location quotient. What these data seem to indicate is that Wisconsin has local distinctiveness in a fairly good mix of industries related to the feedstock and processing components of the bioeconomy. Product development is more speculative, but the state does appear to have some distinctiveness in industries that may be able to replace existing raw materials with biobased products – these include plastics, chemical and solvents manufacturers that might be able to transition to biobased chemicals, for example.

However, Table 6 shows that Wisconsin is not particularly distinctive in the broader field of chemical manufacturing, meaning that it lacks competitiveness in the part of the bioeconomy dedicated to turning feedstocks into chemicals – a sector that many see as the highest-value link on the bioeconomy chain. Neighboring states Illinios and Indiana both have a competitive advantage (i.e. an LQ over 1.0) in this sector. (Table 7 shows that Wisconsin also lags behind these states using another metric, the number of dollars generated by its chemical manufacturing sector.)

[78] One important note is that these high LQ industries are not necessarily the industries employing the most Wisconsin residents – as noted earlier, a high LQ only means that the state is competitive in an industry compared to the U.S., not that it employs more people in that industry than in other industries. In Wisconsin, employment is highest in retail and service industries, which generally pay lower wages than manufacturing and construction industries. However, the state also has a fairly high number of employees in the college and university system, which will clearly play a large role in bioindustry education, research and development.

Table 5: Wisconsin Top 40 Biobased Industries by Location Quotient[79]

Bioindustry Codes: F = feedstock (may be anchor, supplemental, or marginal); PROC = involved in bioindustry process; PROD? = potential end user of biobased products

Bioindustry Code 1	Bioindustry Code 2	sector	Description	Industry employment in WI	WI Location Quotient
F		63	Creamery butter manufacturing	853	19.7
F		50	Malt manufacturing	430	19.1
F		64	Cheese manufacturing	13072	16.8
F		125	Paper and paperboard mills	23003	7.4
PROD?		164	Polish and other sanitation good manufacturing	3846	7.3
F		117	Wood windows and door manufacturing	9761	6.3
F	PROD?	129	Coated and laminated paper and packaging materials	6203	6.2
F		57	Confectionery manufacturing from cacao beans	885	4.8
F		68	Meat processed from carcasses	9907	4.2
F		135	All other converted paper product manufacturing	1526	3.9
F		366	Institutional furniture manufacturing	2439	3.8
F		122	Prefabricated wood building manufacturing	1999	3.8
F		65	Dry, condensed, and evaporated dairy products	1181	3.6
F		11	Cattle ranching and farming	49699	3.4
F		134	Sanitary paper product manufacturing	2426	3.4
PROD?		198	Abrasive product manufacturing	875	3.4
F		123	Miscellaneous wood product manufacturing	2059	3.2
PROD?		110	Footwear manufacturing	1532	3.2
F		60	Frozen food manufacturing	5955	3.1
PROD?		172	Plastics packaging materials, film and sheet	5516	3.0
F		61	Fruit and vegetable canning and drying	5827	3.0
PROD?		346	Motor vehicle body manufacturing	3762	2.8
PROD?		177	Plastics plumbing fixtures and all other plastics products	21422	2.8
F		83	Spice and extract manufacturing	833	2.7
F		82	Mayonnaise, dressing, and sauce manufacturing	654	2.6
PROD?		139	Commercial printing	29721	2.5
F		86	Breweries	1395	2.4
PROD?		158	Fertilizer, mixing only, manufacturing	370	2.2
F		364	Nonupholstered wood household furniture manufacturing	4771	2.2
PROD?		137	Books printing	1606	2.2
F	PROD?	115	Veneer and plywood manufacturing	2194	2.1
F	PROC	124	Pulp mills	294	2.1
F		119	Other millwork, including flooring	2677	2.1
PROD?		196	Lime manufacturing	165	2.0
F		47	Other animal food manufacturing	1492	2.0
F	PROD?	133	Stationery and related product manufacturing	228	2.0
F		126	Paperboard container manufacturing	7739	2.0
F		132	Envelope manufacturing	794	1.9
F		84	All other food manufacturing	2019	1.9
F		120	Wood container and pallet manufacturing	2430	1.9
PROD?		358	Boat building	1860	1.8

[79] The full table of potential biobased industries in Wisconsin, sorted first by bioindustry classification and then by LQ, is at Appendix B.

Table 6: Regional Comparison of Location Quotients in Chemical Manufacturing

	Wisconsin LQ	Illinois LQ	Indiana LQ	Iowa LQ	Michigan LQ	Minnesota LQ
Chemical manufacturing	0.77	1.31	1.66	0.72	0.93	0.53

Gross State Product:

Another way to identify the state's existing industry strengths is to compare the dollars generated by various industries in the state as compared to the dollars generated by the same industry in neighboring states. Table 7 provides the total Gross State Product (GSP) of Wisconsin, Illinois, Indiana, Iowa, Michigan, and Minnesota, and then breaks down GSP by industry in each state. In this table, we have included only those industries most relevant to the biobased economy. A full table, including all industries, can be found at Appendix C.

The data in Table 7 underscores many of the points made throughout this section. The strength of the state's agriculture sector implies a good foundation for the feedstock production necessary for bioindustry development, though Wisconsin is weaker in this area than both Illinois and Iowa. Wisconsin lacks any significant mining activity, making it particularly compelling to turn to domestically-produced energy and fuel sources as an alternative to fossil fuels. The state is extremely strong in the manufacturing sector – stronger than any neighboring state other than Michigan – but weak in chemical manufacturing, potentially the highest-value manufacturing activity in the bioproducts economy. However, as the location quotient data also suggested, Wisconsin is strong in potential end users of bioproducts such as plastics and rubber manufacturing.

Location quotient and GSP data obviously paints only a partial picture of Wisconsin's industrial potential. One fact that these data do not highlight is that many of the state's most competitive industries are located in or around Milwaukee, the state's largest metro center. No economic development strategy in this state can ignore Milwaukee, nor should it: the density of firms in the Milwaukee area, and the concentration of labor there, is critical to the success of Wisconsin's economy in the long run. The fact that bioindustry relies on raw materials that are produced on mainly rural land does not make it a rural economic development strategy only; rather, a good development plan will capitalize on rural *and* urban strengths, and funnel benefits to all areas of the state.

Table 7: Regional Comparison of Gross State Product (GSP) Generated by Selected Biobased Industries (in millions of dollars), 2003

Industry	WI	IL	IN	IA	MI	MN
Total Gross State Product	**$186,350**	**$470,101**	**$201,263**	**$95,569**	**$340,972**	**$198,526**
Agriculture, forestry, fishing, and hunting	**2,678**	**2,810**	**1,791**	**3,067**	**1,632**	**2,623**
Crop and animal production (Farms)	2,162	2,438	1,556	2,797	1,199	2,191
Forestry, fishing, and related activities	524	362	233	274	433	433
Mining	**255**	**982**	**720**	**164**	**551**	**475**
Oil and gas extraction	2	49	8	0	197	(L)
Mining, except oil and gas	253	893	705	163	286	474
Support activities for mining	(L)	40	6	1	70	1
Utilities	**3,120**	**10,377**	**4,466**	**2,244**	**7,193**	**2,837**
Manufacturing	**43,631**	**66,223**	**58,358**	**20,510**	**76,418**	**28,807**
Durable goods	26,160	37,467	39,860	11,461	63,048	19,143
Wood product manufacturing	1,296	588	1,014	787	725	1,352
Machinery manufacturing	5,478	8,582	4,242	3,228	5,298	2,521
Motor vehicle, body, trailer, and parts manufacturing	2,099	4,005	13,360	1,238	39,276	572
Other transportation equipment manufacturing	1,602	308	929	224	703	892
Furniture and related product manufacturing	778	1,094	1,487	633	1,879	621
Miscellaneous manufacturing	1,188	2,833	4,601	327	1,662	1,800
Nondurable goods	17,465	28,686	18,547	9,049	13,391	9,761
Food product manufacturing	4,090	8,463	3,009	3,994	3,088	3,140
Textile and textile product mills	216	236	129	47	133	111
Apparel manufacturing	354	447	97	103	176	156
Paper manufacturing	5,196	1,944	901	603	1,356	1,400
Printing and related support activities	1,993	3,297	1,252	513	1,237	2,090
Petroleum and coal products manufacturing	52	1,854	769	43	200	730
Chemical manufacturing	2,968	7,508	9,450	2,833	3,844	892
Plastics and rubber products manufacturing	2,634	4,918	2,902	928	3,378	1,312
Transportation and warehousing, excluding Postal Service	**5,841**	**17,671**	**6,762**	**3,215**	**8,778**	**7,025**
Air transportation	468	5,390	775	59	2,409	2,937
Rail transportation	455	1,588	647	575	447	585
Water transportation	6	197	175	21	41	35
Truck transportation	3,036	4,672	3,077	1,662	2,657	1,659
Transit and ground passenger transportation	456	781	111	43	212	346
Pipeline transportation	30	144	64	38	190	50
Administrative and waste services	**3,818**	**13,813**	**4,957**	**1,906**	**11,089**	**4,569**
Administrative and support services	3,452	12,611	4,466	1,758	10,154	4,160
Waste management and remediation services	366	1,202	491	149	935	409
Educational services	**1,185**	**4,012**	**1,211**	**684**	**1,515**	**1,275**
Accommodation and food services	**3,900**	**10,140**	**4,218**	**1,859**	**6,903**	**4,255**
Accommodation	1,017	2,712	798	547	1,366	1,187
Food services and drinking places	2,883	7,428	3,419	1,311	5,538	3,067

Wisconsin Needs an Economic Boost[80]

Previous sections focused primarily on Wisconsin's industries. This section looks more closely at another important resource: the state's workforce. One key reason to develop a bioeconomy in Wisconsin is that the state's workforce is falling behind other states in the region – and the U.S. as a whole – on many important measures including educational attainment, wages, and income. As the following demographic and labor force data make clear, those being left farthest behind are low-educated, low-skilled workers, many of whom live in the state's rural areas. A successful bioeconomy plan will need to organize the state's educational systems and workforce development infrastructure to provide training and support for the state's residents so that they may take full advantage of the range of employment opportunities that will arise in this new biobased economy.

The state's workforce is just over three million people. Labor force participation is high – Wisconsin residents are more likely to participate in the labor force than are adults in other states (72.9 percent participation in WI, versus 66.2 percent nationally). As shown in Table 8, the workforce is overwhelmingly white (89 percent, as compared to 70 percent nationally). However, the state's Hispanic and Asian populations are growing rapidly. From 1990-2003, the Hispanic share of the Wisconsin workforce grew fivefold, and now comprises 4.5 percent of the overall workforce. The Asian share more than doubled in the same period, and is now at 1.7 percent. These populations are particularly important to any bioindustry plan, as they make up the largest (and lowest-paid) section of the state's seasonal agricultural workforce.

Wisconsin can be justifiably proud of its educational system. As seen in Table 8, the state's share of high school graduates and students with some college education is greater than the U.S. share. However, the state lags behind the U.S. in terms of the share of the workforce with a bachelor's degree or higher: in 2003, 24.4 percent of the state's workforce had graduated from college or graduate school, whereas the U.S. share was 28.5 percent. This is an important trend for the state to examine as it considers investing in the bioeconomy, where the highest-income jobs will be concentrated in industries requiring a college education (for instance, research and development of new biochemical opportunities; environmental engineering of processing facilities; etc.).

[80] Much of the information in this section comes from the Center on Wisconsin Strategy's 2004 edition of The State of Working Wisconsin, which can be found on the web at http://cows.org/pdf/jobs/soww/rp-soww-04.pdf.

Table 8: Labor Force Demographics, Wisconsin and U.S., 1990 and 2003

	Wisconsin		United States	
	1990	2003	1990	2003
Gender				
Male	53.7%	52.3%	54.9%	53.4%
Female	46.3%	47.7%	45.1%	46.6%
Race / ethnicity				
White	93.6%	88.8%	77.3%	70.4%
Black	3.9%	3.7%	10.8%	10.9%
Hispanic	0.7%	4.5%	8.5%	12.8%
Asian / Pacific Islander	0.7%	1.7%	2.8%	4.1%
Education				
Less than high school	10.5%	10.4%	14.3%	12.8%
High school	44.0%	34.7%	37.9%	30.4%
Some college	22.7%	30.5%	23.4%	28.3%
Bachelor's or higher	22.8%	24.4%	24.5%	28.5%
Age				
16-24 yrs	19.2%	16.7%	17.9%	15.1%
25-54 yrs	68.3%	67.4%	70.2%	69.8%
55 yrs and older	12.5%	15.9%	11.9%	15.1%

Source: Center on WI Strategy, State of Working Wisconsin 2004

In general, analysis of Wisconsin's wage data by the Center on Wisconsin Strategy shows that for workers without 4-year college degrees, wages have been relatively stagnant over the past 25 years. Further, while those with 4-year college degrees appear to be doing much better over time, those with less education are falling farther and farther behind. This mirrors trends in the nation as a whole. For instance, Wisconsin men with college degrees saw a 24 percent increase in wages from 1979 to 2003. However, most Wisconsin men (76 percent) do not have a 4-year college degree. For them, wages were uniformly down from 1979: a decline of 32 percent for high school dropouts, 15 percent for high school graduates, and nearly 6 percentfor those with one to three years of college or other post-secondary school education. For women the picture has been more positive, with increases in wages of more than 40 percent for college graduates from 1979-2003. Wisconsin women without college degrees (75 percent of all working women in the state) also saw some increases: 17 percent increase in wages for those with a high school degree, and 20 percent for those with some college. But to put these apparent gains into real numbers, the median wage for a female worker in the state without a college degree is less than $12/hour.

Another significant trend in the state, and nationally, has been the decline in wages in some industries that used to provide high paying blue-collar jobs – notably, the construction, manufacturing, and transportation industries. Table 9 shows that wages fell in each of these sectors from 1979-2003: by 6.5 percent in construction, 1.7 percent in non-durable manufacturing, by 10.6 percent in durable manufacturing, and by 7.3 percent in transportation, communication and utilities. The most notable wage gains during this period were in the service industry, though agriculture and forestry also posted a major gain of 39.5 percent. This may be due to the consolidation of farms that happened during this same period, as we discussed in the Agricultural section above.

Table 9: Wisconsin Median Hourly Wages by Industry, 1979-2002 (2003 dollars)

	1979	2002	% Change
Construction	$17.98	$16.81	-6.5%
Non-Durable Manufacturing	$15.09	$14.82	-1.7%
Durable Manufacturing	$15.98	$14.28	-10.6%
Transportation, Communication, and Utilities	$18.65	$17.29	-7.3%
Wholesale Trade	$13.90	$14.14	1.8%
Retail Trade	$8.18	$9.73	18.9%
FIRE	$10.78	$14.54	34.9%
Business and Repair Services	$10.55	$14.21	34.8%
Personal Services	$7.34	$9.19	25.3%
Professional and Related Services	$11.78	$14.24	21.0%
Public Administration	$14.63	$16.50	12.7%
Agriculture, Fishing, Forestry, and Mining	$7.65	$10.67	39.5%

Source: Center on WI Strategy, State of Working Wisconsin 2004

Population statistics further underscore the state's need for an economic shot in the arm: the state's population is growing slowly, and aging fast. Wisconsin is home to nearly 5.5 million people, most of whom live in the three metro areas of Milwaukee/Waukesha, Madison, and Green Bay. Wisconsin's population is growing, but not as fast as the overall population of the U.S.: Wisconsin grew by 11.9 percent from 1990 – 2003, while the country grew by 16.9 percent in the same period. However, Wisconsin grew faster in this period than most of the other states in the region, the exception being Minnesota. Our population is aging faster than the U.S. average, and we are not replacing it as quickly: 6.4 percent of Wisconsin's population is under 5 years old, compared to the national average of 6.8 percent, while our percentage of residents 65 and older (13.1 percent) is higher than the national average (12.4 percent).

These demographic and labor force data paint a picture of a state that has long been dependent on fairly high-paying construction and manufacturing jobs; as these jobs have disappeared, they have been replaced by more service-oriented jobs with much lower pay. This fact is reflected in the overall decline in the state median family income. Investing in the bioeconomy may give the state a chance to boost manufacturing and construction, and also create new higher-skill, higher-wage jobs in processing and product development.

Job Opportunities in the Bioeconomy

Because many of the processes, products – and even feedstocks – of the future bioeconomy are as yet unknown, it is difficult to assess the full range of employment opportunities that may be created by that economy. However, data on several existing technologies does indicate the potential for bioindustry to create local jobs.

Biomass Co-firing:

A 2001 Renewable Energy Portfolio Project study estimated that a biomass co-firing facility could create between 3 – 21 full-time jobs per megawatt over a 10-year period, depending on the type of biomass used as fuel:

Employment activity	Switchgrass	Poplar	Willow	Silvicultural Wood	Mill Residue	Urban Wood Waste
Growing, harvesting, preparing (farmers)	0.22-0.36	0.26-0.35	0.17	0.22 (logging equipment operators)	0	0.012-0.157 (mgmt, equipment operators)
Transport (truck drivers)	0.08	0.06	0.051	0.057-0.111	0.057-0.065	0.065
Receive, inspect, store, process (equipment operators and record keepers at plant)	0.010-0.118	0.010-0.118	0.010-0.118	0.010-0.118	0.010-0.118	0.010-0.118
Total person-years per MW over 10 years	12-21	13-20	9-13	11-17	3-7	3-13

Source: Renewable Energy Policy Project, *The Work that Goes Into Renewable Energy* (Nov. 2001)

Ethanol Plants:

In a 2002 study, the USDA examined labor patterns in 21 ethanol plants across the U.S. The study authors determined that these plants employ, on average, 34 persons per plant, though this number depends greatly on the size and age of the plant. Typical plant labor includes:

- general manager
- plant manager
- purchasing manager
- laboratory manager and technicians
- shift supervisors
- plant operators
- maintenance supervisor
- craftsmen
- laborers
- instrument technicians

Source: Shapouri, Hosein and Gallagher, Paul, *2002 Ethanol Cost-of-Production Survey* (USDA July 2002)

Methane Digesters:

In 2001, the Electric Power Research Institute estimated that for every MW of power, a methane digester creates 3.7 construction jobs and 2.3 operating and maintenance jobs.

Source: Electric Power Research Institute, *California Renewable Technology Market and Benefits Assessment*, (Nov. 2001)

Wisconsin's Economic and Workforce Development Infrastructure can Provide Strong Support to the Bioeconomy

As we have pointed out throughout this paper, Wisconsin cannot base an economic plan on existing resources alone. Though short term strategies must take advantage of the state's strengths in agriculture, forestry, manufacturing, and other industries crucial to the bioeconomy, it must also invest heavily in the infrastructure that will anchor future – and as-yet-unknown – bioindustry opportunities. One key piece of this infrastructure is Wisconsin's state-supported economic and workforce development system. This system helps generate new business, arranges financing for existing producers, and trains the state's workers in emerging industries. Though economic and workforce development are often talked about as separate ideas, and in fact are administered by separate state departments, they really work together as the framework that must undergird any serious shift in Wisconsin's economy. This framework is complex; we will give only a very brief overview of it here.

Economic Development: The Wisconsin Department of Commerce (DOC)[81] generally administers the state's economic development programs. This department provides technical and financial assistance to the state's businesses, including investment tax credits, technology assistance and technology bridge grants, venture fund loans, and help with domestic and international export transactions. The DOC is also involved in a number of "state cluster initiatives," which focus economic development assistance on industry clusters such as biotechnology, food processing, manufacturing, and paper.

In addition to the DOC, a fairly decentralized set of county and local economic development organizations exists at the city and county level throughout the state, including Chambers of Commerce, planning commissions, economic development corporations, and business incubators.[82] The University of Wisconsin - Extension Program (UWEX) also plays an important part in economic development in the state: The UWEX program in Community, Natural Resources and Economic Development provides the important link between the University's vast resources and communities and businesses interested in economic development at the local level. For bioindustry, the UWEX statewide program in Agriculture and Natural Resources, which connects the state's farmers to university resources, is of particular interest.[83] UWEX also runs the Center for Community Economic Development in Madison, as well as campus-based programs in Agriculture and Applied Economics, Forest Ecology & Management, Rural Sociology, and Urban Planning.[84]

Workforce Development: The Wisconsin Department of Workforce Development (DWD)[85] administers and oversees the disbursement of state and federal funds for important Wisconsin workforce programs, including "welfare to work" programs, new worker training, dislocated worker support, and unemployment insurance. The programs range from the Wisconsin Works (W2) system, which provides subsidies and training to mostly unskilled residents trying to move off welfare and into the workforce, to the Trade Adjustment Assistance (TAA) system, which

[81] For more information on all these programs, see the DOC website at http://www.commerce.state.wi.us/.
[82] For a list of these agencies by county, see http://www.commerce.state.wi.us/MT/MT-CountyLEDO.html.
[83] For more information on the UWEX Agriculture and Natural Resources program, see http://www.uwex.edu/ces/ag/.
[84] For more information on these programs, see the UWEX website at http://www.uwex.edu/ces/cnred/links.cfm.
[85] For more information on all of DWD's programs, see http://www.dwd.state.wi.us/.

helps workers retrain in new industries when global economic conditions lead to layoffs and terminations, to apprenticeship programs that train workers to become members of skilled trades such as construction. Many of these programs are the result of federal mandates. The DWD's Division of Workforce Solutions also administers the state's Workforce Investment Act (WIA) system, which funnels federal workforce training money to educational and skill-building programs around the state. This last program is probably the most relevant to this paper, so we will describe it in a bit more detail.

The Division of Workforce Solutions delivers services through a network of regional Job Centers, which are public-private partnerships that attempt to bring all workforce training and workforce support services, including services for employers and parents, under one roof. Currently every county in the state has a Job Center.[86] At the regional level, workforce training policy is set by Workforce Development Boards (WDBs), made up of stakeholders such as Technical College representatives, union leaders and local employers. There are eleven WDBs in the state, each representing a different Workforce Development Area.[87]

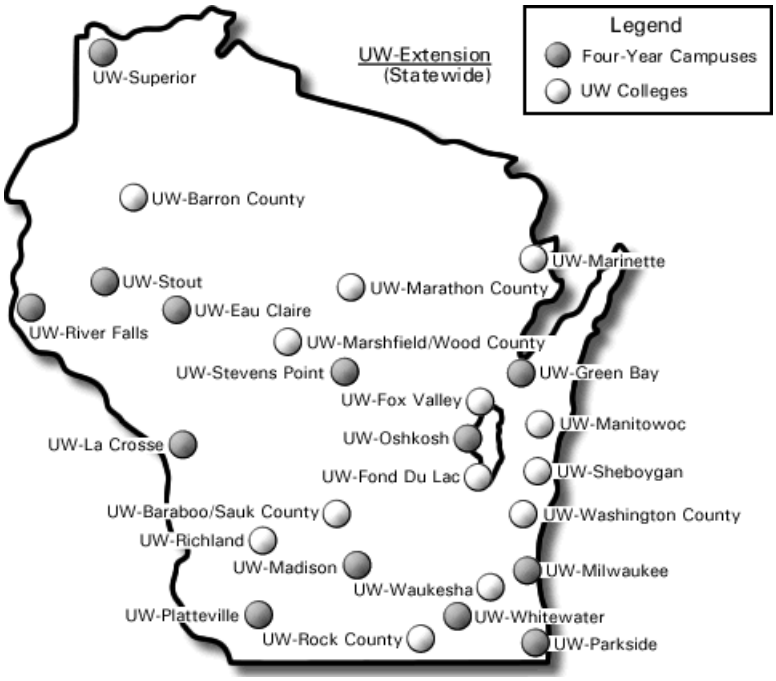
Finally, the DWD has partnered with the Governor's Council on Workforce Investment, created by Governor Doyle by executive order in early 2005. The Council's goal is to provide an overarching, coordinated approach to Wisconsin's workforce development system. The Council is made up of state leaders in business, labor and academia; it is staffed and funded by the DWD.[88] CWI has recently released an RFP to encourage greater regional cooperation and strategic planning on economic and workforce development within particular regions of the state.[89]

Wisconsin's Universities and Technical Colleges Can Provide Strong Support to the Bioeconomy

No discussion of Wisconsin's economic and workforce development infrastructure would be complete without a mention of the state's high-quality university and technical college system. The University of Wisconsin system has thirteen 4-year campuses, thirteen 2-year colleges, and a statewide UW-Extension system (see map), with the flagship campus in Madison. In the 2003-04 academic year, the system enrolled over 160,000 students, about 30,000 of whom were from out of state.[90] The University is funded through a combination of tuition fees, endowments, federal grants and loans, and the state budget.

[86] For links to the state's job centers, see http://www.dwd.state.wi.us/dws/directory/default.htm.
[87] For a list of the Workforce Development Areas, and contact information for the WDBs, see http://www.dwd.state.wi.us/dwdwia/wda_contact_list.htm.
[88] The Governor's Executive Order creating the Council for Workforce Investment can be found at http://www.wi-cwi.org/pdf/executive_order.pdf. Joel Rogers, Director of the Center on Wisconsin Strategy and a member of the bioindustry team, is a member of the Council.
[89] Grant application guidelines and forms are available at http://www.wi-cwi.org/pdf/grow_grant_program_060105.pdf.
[90] University of Wisconsin System, *2004-2005 Fact Book* (November 2003), available at http://www.uwsa.edu/univ_rel/publicat/factcover2004.pdf.

Figure 3: University of Wisconsin System Map



Source: University of Wisconsin System

Research universities and extension programs will clearly play a role as the state explores potential new feedstocks, processes and products for the bioeconomy. Previous sections of this paper have indicated that universities act as partners with government and business in nearly every country and state that is seriously pursuing bioindustry development, especially in the relatively untested arena of replacing petrochemicals with biobased chemicals. While such a tripartite program does not yet exist in Wisconsin, the UW is home to a number of important education and outreach programs related to the bioeconomy, as well as to some key research and development projects, including:

- Research on biogas generation using anaerobic catalysis and/or photocatalysis by Michael E. Zorn of the University of Wisconsin-Green Bay (funded by Focus on Energy). Zorn attempted to use these processes to help convert dairy manure into biogas. This was thought to be the first time that these processes were used for this purpose.
- Research on the production of a diesel-like liquid fuel from carbohydrates commonly found in plants, by UW-Madison College of Engineering researchers George Huber, Juben Chheda, Chris Barrett and Steenbock Professor James Dumesic. The work, profiled in the June 3, 2005 issue of Science, details a four-phase catalytic reactor in which corn and other biomass-derived carbohydrates can be converted to sulfur-free liquid alkanes resulting in an ideal additive for diesel transportation fuel.
- Ongoing research at the UW-Madison Biotechnology Center on using crop plants, such as alfalfa, to produce industrial enzymes. The work is described as involving “molecular approaches to maximize foreign protein expression and methods development for the extraction and purification of commercial proteins from field- grown transgenic alfalfa.”

- UW-Extension collaboration with public and private sector partners to educate state residents on energy efficiency and renewable energy issues, including adoption of improved energy management techniques, technologies to save and generate energy, and incentives available through Wisconsin Focus on Energy.

Non-UW campuses will also play an important role in the bioeconomy. One existing project at Marquette University, funded by Focus on Energy, is a research program focused on using municipal anaerobic digesters as regional energy facilities. This project, headed by Daniel Zitomer, will include setting up a full-size demonstration facility, as well as a detailed cost analysis. Several sources of waste will be turned into methane including beer filters and discarded beer from the Miller brewery in Milwaukee.

Besides the UW system, Wisconsin has sixteen technical college districts throughout the state, with 47 campuses and numerous outreach centers. The technical colleges are funded through property tax revenue, some state and federal grants, and tuition fees. During the 2003-04 academic year, the technical college system enrolled over 68,000 students full-time, including both post-secondary and continuing education students.[91] The technical college system plays an important role in the state's workforce development infrastructure, as the colleges run many of the training programs that workers use to move up the career ladder and into new jobs within the state. Many of these training programs are developed in collaboration with regional employers and in direct response to regional demand.

Wisconsin's technical colleges, especially those located in the more rural parts of the state, already offer a number of training programs in fields that may prove vital to an emerging bioeconomy:

- Chippewa Valley Technical College has an agriscience technician program which includes an emphasis in agronomy/conservation planning.
- Fox Valley Technical College has a degree in Agribusiness and Science Technology.
- Gateway Technical College has a bioscience technician program.
- Madison Area Technical College has a biotechnology laboratory technician program.
- Mid-State Technical College has an agribusiness division.
- Northeast Wisconsin Technical College has an agricultural degree.
- Southwest Wisconsin Technical College has an Agribusiness/Science Technology Program.
- Western Wisconsin Technical College has an Agri-Business Science program.

As we've discussed throughout this paper, many aspects of bioindustry – both technical and economic – are not yet well known. Wisconsin is fortunate to have a strong university system with campuses across the state that can provide crucial research and development help to the emerging bioindustry sector, including basic and applied scientific research, business plan expertise, licensing and patent assistance, and economic development assistance at the more local level. At the same time, the technical colleges can provide job training and skill development for workers hoping to transition into new and emerging bioindustry fields.

[91] More information on the Wisconsin technical college system can be found at http://www.witechcolleges.com.

Wisconsin Has the Multi-Modal Transportation Infrastructure Necessary to Support the Bioeconomy

Wisconsin's transportation infrastructure will be a key part of the bioeconomy, which depends on moving feedstock from farm and forests to processing sites, and moving energy, fuel and bioproducts around the state. In the past thirty years, the state has moved from a system of two-lane highways and small landing strips to one with a robust combination of small and large highways, rail lines, harbors, and airports.

The state now has the sixth highest number of paved roads per capita in the nation, in large part because of the many paved farm roads connecting land to markets around the state. Rail and shipping are also important to the state's economy. The state is currently served by four major railroads, three regional railroads, and four local railroads, which together cover the entire state; about 145 million tons of cargo is carried by these rail systems each year. [92] Wisconsin is also surrounded on three sides by commercially navigable waster systems, the Mississippi River and the Great Lakes. Each year, Wisconsin's 15 commercial ports handle about 44 million tons of cargo, worth an estimated $7 billion.[93] Because water freight is the most cost-efficient way to move bulk commodities such as agricultural products, Wisconsin's geographical location may give the state a competitive advantage in the feedstock transportation necessary to the bioeconomy. Finally, Wisconsin's 134 public use airports handle about 122,000 tons of cargo each year, and move nearly five million people a year in and out of the state.

The multi-modal nature of the state's transportation system means that it is possible to find the most efficient transportation system for each type of biomass feedstock; this is crucial given the bulk and weight of many of those feedstocks. Keeping transportation costs manageable, and relying on many different modes of transportation, will be essential to the state's bioeconomy development. Moreover, these transportation systems will provide bioeconomy jobs, and potentially be end users of the biofuels, bioenergy, and even biobased products the state produces.

Wisconsin Has Already Begun Participating in the Bioeconomy

We have talked throughout this paper about Wisconsin's potential to create a bioeconmy, but the fact is that several companies in the state are already moving in that direction. These existing companies provide a good snapshot of the kinds of bioindustries Wisconsin should encourage in the short term, because the technology on which they are based is already established.

For instance, as of October 2005, Wisconsin has 34 existing or planned anaerobic digesters on livestock operations, the large majority of which were partially funded through the federal Farm Bill. Thirty-three of the digesters use cow manure as biomass; one (Maple Leaf Farm in Franksville) uses duck litter.[94]

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[92] Wisconsin Department of Transportation, *Wisconsin Rail Issues and Opportunities Report (2005)*, available at http://www.dot.wisconsin.gov/projects/state/rail-issues.htm.
[93] Wisconsin Department of Transportation, *Wisconsin's Commercial Ports: Playing a Vital Role in the Flow of Commerce* (Feb. 2004), available at http://www.dot.wisconsin.gov/travel/water/docs/ports-econ-report.pdf.
[94] Digester data gathered by project grantee Resource Strategies Inc.

The state also has four operating ethanol plants: ACE Ethanol in Stanley, Badger State Ethanol in Monroe, United Wisconsin Grain Producers in Friesland, and Utica Energy in Oshkosh. Another, Western Wisconsin Renewable Energy Cooperative, is in the planning stages; it will be built in Boyceville in 2006-07. These are all small facilities, employing around 35 people each.[95]

There is only one biodiesel producer in the state: Renewable Alternatives, located in Green Bay, WI. However, Anamax Grease Services is currently building a cooking-oil-to-biodiesel plant in De Forest. There are five biodiesel fueling stations, located in Cottage Grove, West Salem, Fennimore, De Pere, and Lake Geneva.[96]

Finally, there are two biomass co-firing plants, both owned by Northern State Power, in operation in Wisconsin, one in Ashland and the other in La Crosse.

A more future-looking company in Wisconsin is Virent Energy Systems, based in Madison. Virent has pioneered the Aqueous Phase Reforming (APR) system, which is a carbon-neutral process for manufacturing hydrogen using sugar-based biomass feedstocks. Possible applications include hydrogen fuel cells, biodiesel, and ethanol; however, the technology is not yet commercialized for any of these purposes.[97] Virent provides a good example of a company that, although it does not currently produce bioproducts at a commercial scale, depends heavily on state and federal government incentives for its research. Moreover, whatever it ends up producing, the company will certainly depend on Wisconsin's workforce, education, and transportation infrastructure to bring its products to market in the future.

[95] Ethanol plant data gathered by COWS.
[96] Fueling station locations can be found at http://www.biodiesel.org/buyingbiodiesel/retailfuelingsites/showstate.asp?st=WI.
[97] More information on Virent Energy can be found at www.virent.com.

MOVING FORWARD

The preceding sections make clear that Wisconsin has many of the fundamental pieces in place to pursue a bioeconomy strategy. However, other states and countries that have moved toward this path have encountered significant barriers in bioindustry development. This section provides a brief overview of the most common barriers other places have encountered, as well as some of the general policy mechanisms that can be used to overcome these barriers. Our companion Policy Recommendations paper goes further, exploring Wisconsin-specific barriers and suggested policy avenues for the state to pursue.

General Barriers to Bioeconomy Development

As we have mentioned several times in this paper, Wisconsin is not the first place to think about pursuing a large-scale economic development effort based on existing land resources. Other states in the Midwest, blessed with similar resources and faced with similar economic challenges, have also looked down this road; other countries have also started to build up bioindustry in response to rising oil and gas costs and unstable fuel markets. As these states and countries have begun to move toward bioeconomy development, they have come up against a number of common barriers – barriers that Wisconsin, too, is sure to face as it considers this economic development strategy.

General barriers include:

Lack of capital financing for bioindustry development. Biomass producers are usually not in a position to put up the start-up funds to develop an ethanol or biodiesel plant, a digester, or similar biomass processing facilities.

Lack of outside investment in the bioeconomy. Outside investors and entrepreneurs are wary of investing in bioeconomy projects, where the return on their investment may be slow.

Lack of an established market for biobased products. This is a chicken and egg problem -- there will be no market for bioindustry products without a bioindustry, but there will be no bioindustry without a market. This problem is significant in the agricultural economy especially, where farmers must be confident of a market for a crop in order to move fields over to growing that crop.

Unfair advantage to the fossil fuel industry. The fossil fuel-based economy has decades of government support behind it, as well as the benefit that market prices do not reflect the true social and environmental costs of oil, gas, and coal.

Lack of research and education. There is a basic lack of research on specific bio-based products and their associated benefits and costs; partly as a result, the general public is uneducated about the potential for the bioeconomy to produce social, economic, and environmental benefits.

Entrenched customs in the agricultural economy. Federal and state dollars, and private research grants, are generally directed at dominant crops and processes (e.g. corn, sugar-based ethanol), leaving relatively little funding for more promising alternative crops or less intensive processes.

Lack of coordination among key bioeconomy players:

- At the grower level, among farmers and rural landowners whose operations are too small on their own to justify bioindustry investment,
- At the "grasstops" among government, academia, and industry,
- At the grassroots among growers, environmental groups, labor and economic development groups, and community groups,
- Within government itself among agencies (e.g. agriculture, forestry, commerce, workforce development, transportation) involved in the bioeconomy.

Lack of business infrastructure in rural areas. Many rural areas lack internet access, cellular service, and working airports; this can discourage outside businesses from locating in those areas.

General Policy Options Available to Promote the Bioeconomy

State and national governments interested in bioindustry development have been proactive in instituting policies to overcome some of the more obvious barriers to this development. As Wisconsin moves forward with a biobased strategy, it may be useful to note the types of policy mechanisms other governments have used or are using to spur the biobased economy in their own regions. These policies are diverse and various, but they can be generally grouped into six categories:[98]

- Regulations governing access to the market and production or purchase obligations (e.g., Renewable Portfolio Standards, Renewable Fuel Standards, and grid connection policies such as interconnection standards and net metering)
- Financial incentives (e.g., tax incentives, credits, rebates)
- Industry standards, permitting, and codes
- Education and information campaigns
- Stakeholder involvement
- Government investment in research and development

There is obviously room within each of these categories to target policies toward specific projects. For instance, policymakers interested in promoting small-scale, distributed technologies usually provide financial incentives and regulatory supports to the end customer, whereas promoting large scale projects requires investment in large entities like utilities. In general, however, the key to providing policy supports for renewable energy, fuel, and product development is the creation of "consistent, reliable markets" that "allow for the entry and maturation of small- and medium-scale enterprises, which have provided the bulk of the technological innovation that has driven down…costs."[99]

Governments use a variety of these policy mechanisms in combination to support burgeoning renewable energy and fuel markets (in the bioproducts industry, support mainly comes through investments in research and development). For instance, most countries seriously interested in developing renewable energy markets use either a quota system like the Renewable Portfolio

[98] Sawin, Janet, *National Policy Instruments: Policy Lessons for the Advancement & Diffusion of Renewable Energy Technologies Around the World*, International Conference for Renewable Energies (January 2004).
[99] *Id.*

System (found in 18 U.S. states, the UK, Japan, Italy and Australia; this policy may be implemented nationally in the U.S. under the new energy bill), or a feed-in tariff system requiring utilities to give grid access and guaranteed rates to small energy producers (found in Germany, Denmark, Spain, France, Austria, Portugal, Greece, and South Korea).

Financial incentives used across the world include investment tax credits (Japan provides these for solar photovoltaic (PV) systems, and has found them to be a good way to help small-scale, expensive technologies mature), production tax credits (the U.S. is the leader here), carbon taxes, tariff reductions, rebates and payments for production/installation (California provides payments for each kilowatt-hour (kWh) produced by renewable energy projects), etc. One popular mechanism to address the high capital costs of new renewable technologies is the low-interest loan or loan guarantee – for instance, Germany has its renewable energy loans guaranteed by the government, as does Japan. Developing countries are most likely to use this mechanism.

The range of specific bioindustry policies and developments that exist around the world is enormous – the preceding section only begins to explore some of these efforts. What types of policies might make the most sense in Wisconsin is the subject of a separate paper (to be produced during Phase IV of the Energy Center of Wisconsin biobased economy study). However, based on experiences in other countries, it does seem clear that whatever policies Wisconsin decides to enact to encourage bioindustry development must be consistent and long-term, and must provide the security and stability necessary to any newly emerging market.

CONCLUSION

In writing this briefing paper, we set out to explore the question of whether the state of Wisconsin has many of the elements necessary to build a strong, vibrant economy based on bioindustry. We believe the answer to that question to be yes. The state has a diverse mix of the ingredients necessary to build such an economy: raw materials, both in agriculture and forestry; a strong manufacturing infrastructure, including facilities and highly-skilled labor; a strong university and technical college system, including internationally-known research facilities; and a strong workforce development system with the capacity to train workers in the new skills necessary to any emerging industry. The state also already has industry concentrations in many of the primary and secondary industries that will make up a biobased sector, including not only the biomass growers and producers but also the manufacturing facilities, processors, and potential end users of various bioproducts. These elements could combine to make Wisconsin very competitive in the bioindustry arena.

From a national and global economic perspective, there seems to be an emerging market for bioindustry products – certainly for bioenergy and biofuels, given the rising costs of oil and natural gas, and, in the longer run, for bioproducts that can replace petroleum-based products subject to the same costs. The U.S. has made great gains in sugar-based ethanol production but has been slower to move toward cellulosic ethanol and other biofuel production; these may be good markets for Wisconsin to explore. Bioproduct development has been slow throughout the world, and may be another productive area for Wisconsin to move into; however, Wisconsin lacks industry concentration in the chemical plants that are crucial to this sector. Finally, because the energy security of the entire world is threatened due to the high cost, increasing scarcity, and political vulnerability of a petroleum-based economy – and because much of the world is bound by the Kyoto Protocol to drastically reduce fossil fuel emissions – there will likely be a market for Wisconsin's bioindustry products beyond the borders of the U.S.

To create the bioeconomy, however, Wisconsin needs more than its existing resources and the will to move forward. This state will need to pursue specific policies targeted toward creating a successful bioeconomy, one that includes a range of rural and urban jobs, entrepreneurship opportunities, ownership opportunities for rural landowners, and economic incentives balanced with environmental protections. Accomplishing this task will require the state's major institutions – government, academia, business, labor, and community – to work together and mutually reinforce one another. It is a huge task, but one that we feel the state cannot afford to ignore.

Appendix A: Bioindustry-Related Programs in the 2005 Energy Bill[100]

- Title II, Sec. 210: Creates a $50 million annual grant program from 2006-2016, that will provide money to offset the cost of projects to develop or research opportunities to improve the use of, or add value to, biomass. Grants are limited to $20/ton of green biomass delivered, with a maximum value of $500,000.
- Title VII, Sec. 741: Authorizes a $55 million federal grant program for replacement, retrofit, or new purchase clean school buses. These buses can be operated on ultra low sulfur diesel fuel, biodiesel, LNG, or ethanol/methanol blended diesel.
- Title IX, Sec. 921: Provides funding for distributed energy technology research, development, demonstration, and commercial application. The program is funded at $240 million in 2007, $255 million in 2008, and $273 million in 2009.
- Title IX, Sec. 931 & 932: Provides targeted funding for the development of bioenergy equal to $213 million in 2007, $251 million in 2008, and $274 million in 2009. Included in this funding is provision that funnels some of this money toward demonstrations of the commercial applicability of integrated biorefineries, and biodiesel generators as university power sources.
- Title IX, Sec. 941: Increases the funding and duration of the Biomass Research and Development Act of 2000 from $54 million/year from 2002-2007, to $200 million/year from 2006-2015.
- Title IX, Sec. 942: Sets a goal of developing the capacity to produce 1 billion gallons of cellulosic ethanol annually by 2015. Instructs the Secretary of Energy to develop a production incentive for cellulosic ethanol once the U.S. reaches an annual production capacity of 100 million gallons. Total funding for the future incentives is set at $250 million.
- Title IX, Sec. 944: Authorizes $1,000,000 for FY 2006 and appropriate sums for years 2007 through 2015 for marketing assistance for biobased products.
- Title IX, Sec. 945: Established the Regional Bioeconomy Development Grant program. Authorizes $1,000,000 in FY 2007 and appropriate sums from 2007 though 2015. Grants are available to regional development associations and agricultural or trade associations for the purposes of developing regional bio-based economies.
- Title IX, Sec. 946: Provides funding for up to five demonstration project on efficient preprocessing and multiple-crop harvesting techniques for the production of cellulosic ethanol. Federal funding may not comprise more than 20 percent of total project cost and the budget for all demonstration projects is set at $5 million/year from 2006-2010.
- Title XII, Sec. 1251: Requires all utilities to make net metering available to its customers upon request within two years.
- Title XII, Sec. 1254: Amends the Public Utility Regulatory Policy Act (PURPA) of 1978 to require that all utilities make interconnection services available to customers upon their

[100] This information is taken directly from the conference version of the Energy Policy Act of 2005, from the title and sections noted in the text. The bill was accessed 8/10/05 on the Senate Energy and Natural Resources Committee's site, available at: http://energy.senate.gov/public/_files/ConferenceReport0.pdf. Another summary of relevant Energy Bill provisions can be found on the National Association of State Energy Officials (NASEO) website, at http://www.naseo.org/committees/govaffairs/legislation/EPACT_2005_Summary.pdf.

request within two years. The interconnection standards are to be based upon the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547.

- Title XIII Sec. 1341: Provide a tax credit between 50 percent and 80 percent of the incremental cost of an alternative fuel vehicle. Alternative fuels include E85 as well as other fuel sources.
- Title XIII. Sec 1342: Allows a 30 percent tax credit for any qualified alternative fuel refueling property placed into service by the taxpayer during the taxable year.
- Title XIII. Sec. 1345: Established the Small Agri-biodiesel Producer Credit. This section gives biodiesel producers producing less than 60,000 gallons per year a 10 cent credit per gallon of qualified biodiesel.
- Title XV, Sec. 1501: Establishes a renewable fuel standard that requires the consumption of 7.5 billion gallons of ethanol by 2012. In order to spur the development of cellulosic ethanol technology, each gallon of cellulosic ethanol counts as 2.5 gallons of traditional ethanol.
- Title XV, Sec. 1510: Creates a loan guarantee program for the construction of facilities that turn municipal solid waste (MSW) and/or cellulosic biomass into fuel ethanol and other commercial byproducts. The loan guarantee program has a duration of 10 years.
- Title XV, Sec. 1511: Creates a loan guarantee program for 4 demonstration plants producing cellulosic ethanol or sucrose ethanol. At least one project must use cereal straw as a feedstock and at least one project must use municipal solid waste. Maximum loan guarantees are set at $250,000,000 per project.
- Title XV, Sec. 1512: Amends the Clean Air Act to include a grant assistance program for the construction of cellulosic and waste-derived ethanol production facilities. This program is funded at the following levels: $100 million in 2006, $250 million in 2007, $400 million in 2008.
- Title XV, Sec 1514: Established the Advanced Biofuel technologies Program. The program will fund demonstration projects for at least 4 different cellulosic ethanol conversion techniques and at least 5 techniques for producing useful byproducts. The program is funded at $110,000,000 in each fiscal year 2005 through 2009.
- Title XVII: Establishes an Innovative Technologies Loan Guarantee program for (among other things) renewable energy systems.

Appendix B: Potential Biobased Industries in Wisconsin, Sorted First by Bioeconomy Codes, then by Location Quotient

Bioindustry Codes: F = feedstock (may be anchor, supplemental, or marginal); PROC = involved in bioindustry process; PROD? = potential end user of biobased products

Bioindustry Code 1	Bioindustry Code 2	sector	description	Industry employment in WI	WI Location Quotient
F		63	Creamery butter manufacturing	853.4	19.7
F		50	Malt manufacturing	430.1	19.1
F		64	Cheese manufacturing	13072.2	16.8
F		125	Paper and paperboard mills	23003.6	7.4
F		117	Wood windows and door manufacturing	9761.6	6.3
F	PROD?	129	Coated and laminated paper and packaging materials	6203.6	6.2
F		57	Confectionery manufacturing from cacao beans	885.5	4.8
F		68	Meat processed from carcasses	9907.7	4.2
F		135	All other converted paper product manufacturing	1526.8	3.9
F		366	Institutional furniture manufacturing	2439.5	3.8
F		122	Prefabricated wood building manufacturing	1999.3	3.8
F		65	Dry, condensed, and evaporated dairy products	1181.5	3.6
F		11	Cattle ranching and farming	49699.2	3.4
F		134	Sanitary paper product manufacturing	2426.2	3.4
F		123	Miscellaneous wood product manufacturing	2059.3	3.2
F		60	Frozen food manufacturing	5955.5	3.1
F		61	Fruit and vegetable canning and drying	5827.2	3.0
F		83	Spice and extract manufacturing	833.4	2.7
F		82	Mayonnaise, dressing, and sauce manufacturing	654.1	2.6
F		86	Breweries	1395.6	2.4
F		364	Nonupholstered wood household furniture manufacturing	4771.4	2.2
F	PROD?	115	Veneer and plywood manufacturing	2194.4	2.1
F	PROC	124	Pulp mills	294.7	2.1
F		119	Other millwork, including flooring	2677.9	2.1
F		47	Other animal food manufacturing	1492.2	2.0
F	PROD?	133	Stationery and related product manufacturing	228.9	2.0
F		126	Paperboard container manufacturing	7739.3	2.0
F		132	Envelope manufacturing	794.5	1.9
F		84	All other food manufacturing	2019.5	1.9
F		120	Wood container and pallet manufacturing	2430.5	1.9
F		79	Other snack food manufacturing	1220.6	1.7
F		2	Grain farming	21068.1	1.7
F		14	Logging	4621.9	1.7
F		67	Animal, except poultry, slaughtering	5317.6	1.7

Bioindustry Codes: F = feedstock (may be anchor, supplemental, or marginal); PROC = involved in bioindustry process; PROD? = potential end user of biobased products

F		3	Vegetable and melon farming	4268.9	1.5
F		128	Surface-coated paperboard manufactuing	74.0	1.4
F		69	Rendering and meat byproduct processing	249.0	1.4
F		58	Confectionery manufacturing from purchased chocolate	1092.9	1.3
F		369	Custom architectural woodwork and millwork	350.2	1.3
F	PROD?	116	Engineered wood member and truss manufacturin	1352.8	1.3
F		5	Fruit farming	4992.6	1.3
F		66	Ice cream and frozen dessert manufacturing	566.4	1.2
F	PROD?	368	Wood office furniture manufacturing	712.8	1.2
F		74	Cookie and cracker manufacturing	826.6	1.2
F	PROD?	362	Wood kitchen cabinet and countertop manufacturing	3630.3	1.2
F		73	Bread and bakery product, except frozen, manufacturing	6033.2	1.2
F	PROD?	114	Reconstituted wood product manufacturing	492.0	1.2
F		118	Cut stock, resawing lumber, and planing	511.6	1.2
F	PROD?	112	Sawmills	2715.1	1.1
F		46	Dog and cat food manufacturing	415.2	1.1
F		1	Oilseed farming	4369.4	1.1
F	PROD?	113	Wood preservation	299.8	1.1
F		121	Manufactured home, mobile home, manufacturing	1190.5	1.1
F		481	Food services and drinking places	215660.1	1.1
F		13	Animal production, except cattle and poultry	9247.9	1.0
F		405	Food and beverage stores	62961.3	1.0
PROC		394	Truck transportation	56510.2	1.5
PROC		407	Gasoline stations	24434.6	1.3
PROC	S	30	Power generation and supply	9767.4	1.2
PROD?		164	Polish and other sanitation good manufacturing	3846.7	7.3
PROD?		198	Abrasive product manufacturing	875.5	3.4
PROD?		110	Footwear manufacturing	1532.1	3.2
PROD?		172	Plastics packaging materials, film and sheet	5516.8	3.0
PROD?		346	Motor vehicle body manufacturing	3762.5	2.8
PROD?		177	Plastics plumbing fixtures and all other plastics products	21422.2	2.8
PROD?		139	Commercial printing	29721.2	2.5
PROD?		158	Fertilizer, mixing only, manufacturing	370.7	2.2
PROD?		137	Books printing	1606.1	2.2
PROD?		196	Lime manufacturing	165.3	2.0
PROD?		358	Boat building	1860.7	1.8
PROD?		167	Printing ink manufacturing	445.4	1.7
PROD?		161	Paint and coating manufacturing	1551.5	1.7
PROD?		165	Surface active agent manufacturing	220.6	1.5
PROD?		151	Other basic organic chemical manufacturing	1247.8	1.4
PROD?		103	Other miscellaneous textile product mills	1201.9	1.4
PROD?		101	Textile bag and canvas mills	798.2	1.3

Bioindustry Codes: F = feedstock (may be anchor, supplemental, or marginal); PROC = involved in bioindustry process; PROD? = potential end user of biobased products

PROD?		178	Foam product manufacturing	1477.2	1.2
PROD?		195	Other concrete product manufacturing	1440.4	1.1
PROD?		194	Concrete pipe manufacturing	275.8	1.1
PROD?		192	Ready-mix concrete manufacturing	2650.5	1.1
PROD?		174	Laminated plastics plate, sheet, and shapes	500.5	1.1

Appendix C: Regional Comparison of Gross State Product (GSP) by Industry (in millions of dollars), 2003

Industry	Illinois	Indiana	Iowa	Michigan	Minnesota	Wisconsin
Total Gross State Product	$470,101	$201,263	$95,569	$340,972	$198,526	$186,350
PRIVATE INDUSTRIES	**$426,283**	**$182,703**	**$84,873**	**$307,525**	**$179,234**	**$166,888**
Agriculture, forestry, fishing, and hunting	**2,810**	**1,791**	**3,067**	**1,632**	**2,623**	**2,678**
Crop and animal production (Farms)	2,438	1,556	2,797	1,199	2,191	2,162
Forestry, fishing, and related activities	362	233	274	433	433	524
Mining	**982**	**720**	**164**	**551**	**475**	**255**
Oil and gas extraction	49	8	0	197	(L)	2
Mining, except oil and gas	893	705	163	286	474	253
Support activities for mining	40	6	1	70	1	(L)
Utilities	**10,377**	**4,466**	**2,244**	**7,193**	**2,837**	**3,120**
Construction	**20,298**	**8,478**	**3,523**	**13,544**	**9,109**	**7,457**
Manufacturing	**66,223**	**58,358**	**20,510**	**76,418**	**28,807**	**43,631**
Durable goods	37,467	39,860	11,461	63,048	19,143	26,160
Wood product manufacturing	588	1,014	787	725	1,352	1,296
Nonmetallic mineral product manufacturing	1,575	1,306	750	1,819	831	1,137
Primary metal manufacturing	1,896	5,435	466	2,128	420	1,453
Fabricated metal product manufacturing	8,687	4,627	1,314	6,189	3,387	5,015
Machinery manufacturing	8,582	4,242	3,228	5,298	2,521	5,478
Computer and electronic product manufacturing	5,867	2,062	1,460	2,353	6,856	3,065
Electrical equipment and appliance manufacturing	2,660	1,125	1,214	1,552	771	3,498
Motor vehicle, body, trailer, and parts manufacturing	4,005	13,360	1,238	39,276	572	2,099
Other transportation equipment manufacturing	308	929	224	703	892	1,602
Furniture and related product manufacturing	1,094	1,487	633	1,879	621	778
Miscellaneous manufacturing	2,833	4,601	327	1,662	1,800	1,188
Nondurable goods	28,686	18,547	9,049	13,391	9,761	17,465
Food product manufacturing	8,463	3,009	3,994	3,088	3,140	4,090
Textile and textile product mills	236	129	47	133	111	216
Apparel manufacturing	447	97	103	176	156	354
Paper manufacturing	1,944	901	603	1,356	1,400	5,196
Printing and related support activities	3,297	1,252	513	1,237	2,090	1,993
Petroleum and coal products manufacturing	1,854	769	43	200	730	52
Chemical manufacturing	7,508	9,450	2,833	3,844	892	2,968

Industry	Illinois	Indiana	Iowa	Michigan	Minnesota	Wisconsin
Plastics and rubber products manufacturing	4,918	2,902	928	3,378	1,312	2,634
Wholesale trade	**33,980**	**10,978**	**5,830**	**20,308**	**14,331**	**10,622**
Retail trade	**31,442**	**14,969**	**7,293**	**25,985**	**14,675**	**13,865**
Transportation and warehousing, excluding Postal Service	**17,671**	**6,762**	**3,215**	**8,778**	**7,025**	**5,841**
Air transportation	5,390	775	59	2,409	2,937	468
Rail transportation	1,588	647	575	447	585	455
Water transportation	197	175	21	41	35	6
Truck transportation	4,672	3,077	1,662	2,657	1,659	3,036
Transit and ground passenger transportation	781	111	43	212	346	456
Pipeline transportation	144	64	38	190	50	30
Other transportation and support activities	3,217	1,095	394	1,628	1,014	769
Warehousing and storage	1,822	870	423	1,364	537	651
Information	**20,498**	**4,938**	**3,323**	**10,005**	**7,436**	**5,952**
Publishing including software	5,254	1,099	807	3,127	2,451	1,370
Motion picture and sound recording industries	614	106	77	370	187	171
Broadcasting and telecommunications	12,605	3,511	1,909	5,859	3,857	3,617
Information and data processing services	2,003	225	515	637	925	785
Finance and insurance	**46,760**	**12,026**	**9,932**	**19,761**	**20,863**	**13,634**
Federal Reserve banks, credit intermediation and related services	19,607	6,147	3,577	10,536	10,169	5,258
Securities, commodity contracts, investments	12,446	1,094	493	2,702	3,992	2,464
Insurance carriers and related activities	14,779	4,758	5,861	6,418	6,570	5,938
Funds, trusts, and other financial vehicles	586	49	14	219	220	131
Real estate, rental, and leasing	**55,934**	**19,132**	**8,645**	**37,597**	**22,134**	**20,290**
Real estate	50,669	17,346	7,865	35,317	20,371	19,196
Rental and leasing services and lessors of intangible assets	5,259	1,788	777	2,278	1,755	1,095
Professional and technical services	**38,107**	**7,391**	**2,965**	**27,130**	**11,740**	**7,739**
Legal services	8,868	1,532	696	3,243	2,317	1,593
Computer systems design and related services	5,285	1,140	398	5,488	2,584	1,463
Other professional, scientific and technical services	23,926	4,722	1,874	18,420	6,835	4,693
Management of companies and enterprises	**10,237**	**2,273**	**605**	**7,753**	**6,536**	**3,877**
Administrative and waste services	**13,813**	**4,957**	**1,906**	**11,089**	**4,569**	**3,818**
Administrative and support services	12,611	4,466	1,758	10,154	4,160	3,452

Industry	Illinois	Indiana	Iowa	Michigan	Minnesota	Wisconsin
Waste management and remediation services	1,202	491	149	935	409	366
Educational services	**4,012**	**1,211**	**684**	**1,515**	**1,275**	**1,185**
Health care and social assistance	**28,596**	**13,395**	**6,230**	**22,159**	**14,666**	**14,063**
Ambulatory health care services	14,000	7,234	3,244	11,364	7,923	7,554
Hospitals and nursing and residential care facilities	12,013	5,060	2,416	9,170	5,157	5,212
Social assistance	2,634	1,130	581	1,668	1,605	1,321
Arts, entertainment, and recreation	**4,189**	**2,608**	**967**	**2,815**	**1,657**	**1,292**
Performing arts, museums, and related activities	1,608	817	214	874	807	518
Amusements, gambling, and recreation	2,581	1,791	753	1,941	850	774
Accommodation and food services	**10,140**	**4,218**	**1,859**	**6,903**	**4,255**	**3,900**
Accommodation	2,712	798	547	1,366	1,187	1,017
Food services and drinking places	7,428	3,419	1,311	5,538	3,067	2,883
Other services, except government	**10,668**	**4,291**	**1,956**	**6,956**	**4,430**	**3,841**
GOVERNMENT	**$43,868**	**$18,599**	**$10,716**	**$33,496**	**$19,342**	**$19,488**
Federal civilian	7,227	2,675	1,245	3,657	2,738	2,937
Federal military	2,016	455	283	537	410	379
State and local	34,642	15,467	9,189	29,300	16,195	16,173