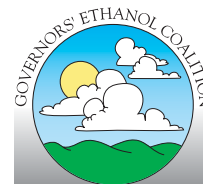




Cellulose Prairie

*Biomass Fuel Potential
in Wisconsin and the Midwest*



April 2007

by

Brett Hulsey

Better Environmental Solutions

Cellulose Prairie:

Biomass Fuel Potential in Wisconsin and the Midwest

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For the Governors' Ethanol Coalition

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Background

The Governors' Ethanol Coalition believes that pilot-scale demonstrations of emerging cellulosic technologies are keys to moving production forward. These demonstrations will likely aid producers and farmers in working through logistical and production challenges more quickly and cost effectively than other means. Basic information on the potential of cellulosic demonstrations, associated benefits, and other state and local issues would assist in developing both communications and policy positions. In addition, information on the potential for federal-state-private cost share to diffuse the risks of such projects would also be useful.

This report analyzes the potential impacts of cellulosic demonstration projects in Wisconsin as a case study of the benefits and costs of a pilot-scale demonstration. It provides information about the potential for job creation, technology demonstration, testing of biomass collection and utilization, cost-share and other issues. For more, see www.ethanol-gec.org.

Summary

Cellulosic biomass like switchgrass, wood, and crop residues; as well as manure; are great potential biofuels and biopower sources. Twelve Midwestern states have up to 231 million tons of potential excess biomass each year. If converted to ethanol, this could yield 13.9 billion gallons, more than doubling current ethanol production. This excess biomass could also be burned replacing 154 million tons of coal, equivalent to one-third (37%) of the coal burned in the 12 Midwestern states each year. These states have half of the nation's 466 million tons of potential excess biomass, making the Midwest the potential biofuel Saudi Arabia of America.

Wisconsin alone has almost 15 million tons of potential excess biomass that could produce 1.3 billion gallons of ethanol per year and could displace half of the 2.6 billion gallons of gasoline Wisconsin consumed last year. This is in addition to Wisconsin's 252 million gallons of current corn ethanol production. If burned, this biomass could replace 15 million tons of coal, equivalent to 56% of Wisconsin's total coal use.

Cellulosic ethanol produces a mash that can be dried and burned, so the fuel can be used as a solid or liquid. These biomass materials are excess or surplus and can be harvested sustainably to maintain forest and soil health.

Additional government investments and actions could realize this potential and the goals of the president, governors, and Energy Foundation's "New Harvest" report to wean America from oil and coal use.

Wisconsin has major untapped biomass reserves. While the state may not be able to match Silicon Valley as a high-tech leader, it could be the Cellulose Prairie and Forest for biopower and biofuels. The state's great natural resources are its forests, wood products, corn production, and therefore corn stover (a major biomass source); dairy and beef cattle (a manure source); and prairie grasslands in the Conservation Reserve Program and other conservation programs. The state also has the largest papermakers in the country, with many mills using wood for energy and looking for new sources of energy and revenue to compete with stiff international competition.

This is important because Wisconsin is also almost totally energy dependent, importing \$18.5 billion of energy. Two-thirds of this money leaves the state, resulting in a loss of \$12 billion and 300,000 jobs. Expanding biofuel production will reduce this job and income drain, and create better markets for Wisconsin's agricultural and forest productions.

These biofuel sources could significantly reduce the carbon footprint from gasoline and coal, the largest CO2 sources in Wisconsin. They can also reduce CO2 by sequestering carbon. Conservation tillage, grasslands and forests conservation can store from 0.5-6 tons of carbon per acre per year. Creating more demand for these conservation practices will likely expand them. The Farmers' Union is now recruiting farmers for carbon sequestration contracts with the Chicago Climate Exchange.

This report also highlights promising projects in Wisconsin from the Flambeau Paper Mill in the north to the Belmont Bio-Ag in the south to advanced ethanol projects in the east. Several Wisconsin ethanol plants are now employing advanced biofuel processes like fractionation or are studying advanced biopower projects.

This report uses data from peer-reviewed journals, the U.S. Departments of Energy, National Renewable Energy and Oak Ridge National Laboratories, U.S. Department of Agriculture Forest Products Lab, Natural Resources Conservation Service, Wisconsin State Department of Agriculture, Trade and Consumer Protection, Public Service Commission, and Division of Energy.

Governor Jim Doyle has also made promoting the bioeconomy a major part of his Energy Independence agenda with a goal of 25% biofuels and renewable energy by 2025 ("25 by 25"), appointing a Global Warming Taskforce and BioIndustry Consortium. His budget



proposal includes \$30 million for bioproject loans and grants, \$5 million for cellulosic research, \$4 million for venture capital, and \$1 million for new E 85 and biodiesel pumps.

But federal policies and money are needed to keep this biofuels train rolling. The biomass potential shown in this report cannot be realized without government actions:

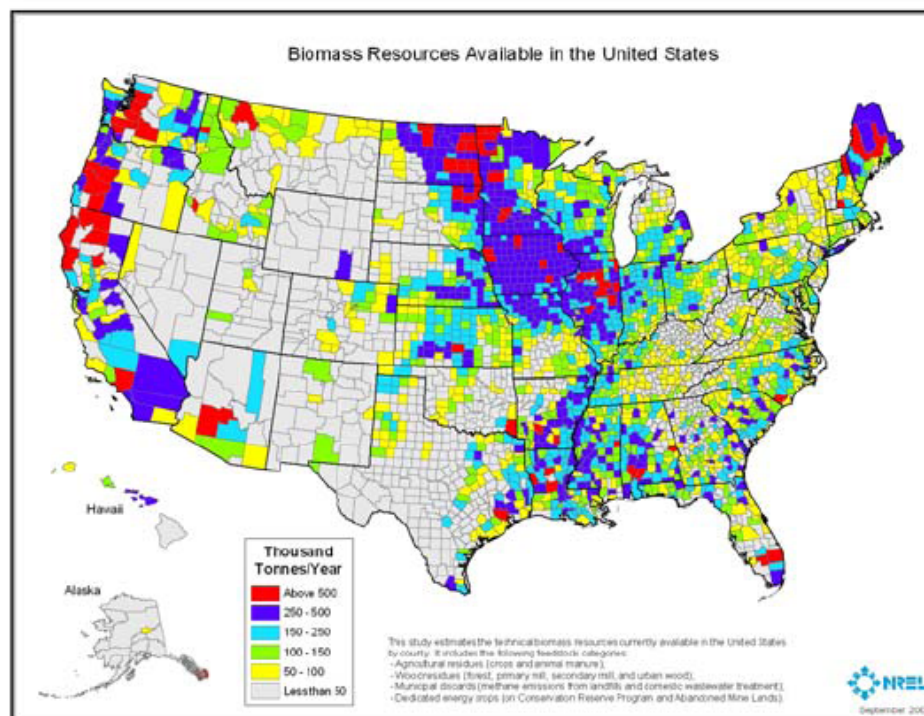
1. Fund 10 pilot cellulosic plant projects to develop and refine technologies for full-scale application;
2. Expand the grant and loan programs to promote cellulosic ethanol and advanced biopower projects;
3. Enact policies to promote 25% biofuels use by 2025 (“25 by 25”);
4. Create an Energy Reserve Program of 10-20 million acres to help farmers and landowners produce more biomass such as switchgrass, wood fuel and other biopower feedstocks; and
5. Develop at least a \$100 million per state biofuel venture capital fund using government investments to spur new business startups.

If we take these steps, America will accelerate its efforts to reduce dependence on foreign oil and coal, and save money while creating jobs and helping family farmers.



The Midwest is the Biofuels Belt

Midwestern states constitute a major biomass resource belt that stretches from Ohio to North Dakota and from Wisconsin to Kansas, as indicated on the map below from a 2005 U.S. Department of Energy, National Renewable Energy Lab study.¹ Blue counties have more than 250,000 tons/year and most green counties have more than 100,000 tons/year of potential biomass fuel. A few red counties possess more than 500,000 tons per year.



¹ Milbrandt, A. et al, “A Geographic Perspective on the Current Biomass Resource Availability in the United States,” USDOE NREL, 2005, page 44, www.nrel.gov/docs/fy06osti/39181.pdf.

The 12 Midwestern states have very few oil and gas resources but have more than 231 million tons per year of potential biofuels, which could produce 13.9 billion gallons of ethanol fuel or displace 154 million tons of coal.² See Table 6 on page 26 for a state-by-state summary of excess biomass resources.

Our analysis shows that the Midwest has half of the nation's 466 million tons of potential excess biomass, making it the potential biofuel Saudi Arabia of America. These states have three-fourths of the nation's switchgrass and excess crop residue resources.

It should be noted that excess biomass materials can be harvested while protecting our forest and field health. As we discuss in the section on environmental issues on page 32, biomass removal can help reduce nitrogen needs fertilizer. Much of this biomass is converted to CO₂ through decay or burning now. Removal and fuel use allows capturing some energy before it is converted to CO₂ and not burning fossil fuels. The forest material can be removed through sustainable forest management plans.

A 2005 U.S. Department of Energy and Department of Agriculture study shows the extent of the biomass potential:

“Current availability is the baseline that summarizes sustainable biomass resources under current crop yields, tillage practices (20-40 percent no-till for major crops), residue collection technology (~40 percent recovery potential), grain to ethanol and biodiesel production, and use of secondary and tertiary residues. In sum, the amount of biomass currently available for bioenergy and bioproducts is about 194 million dry tons annually. This is about 16 percent of the 1.2 billion dry tons of plant material produced on agricultural land. It includes 113 million dry tons of crop residues, 15 million dry tons of grain (starch) used for ethanol production, 6 million dry tons of corn fiber, and 60 million dry tons of animal manures and residues (e.g., MSW and fats). **The single largest source of this current potential is corn residues or corn stover, totaling close to 75 million dry tons.**³”
(Emphasis added)

² US DOE, Oak Ridge National Labs, “Biofuels and Agriculture,” 2001, <http://bioenergy.ornl.gov/main.aspx>. We conservatively assume 60 gallons ethanol/ton biomass and 12 MBTUs/pound for biomass and 18 MBTU/pound for Powder River Basin coal.

³ USDA and USDOE, “Biomass as Feedstock for a Bioenergy and Bioproducts Industry,” 2005, page 21, www1.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf.

Wisconsin has Biofuel Advantages

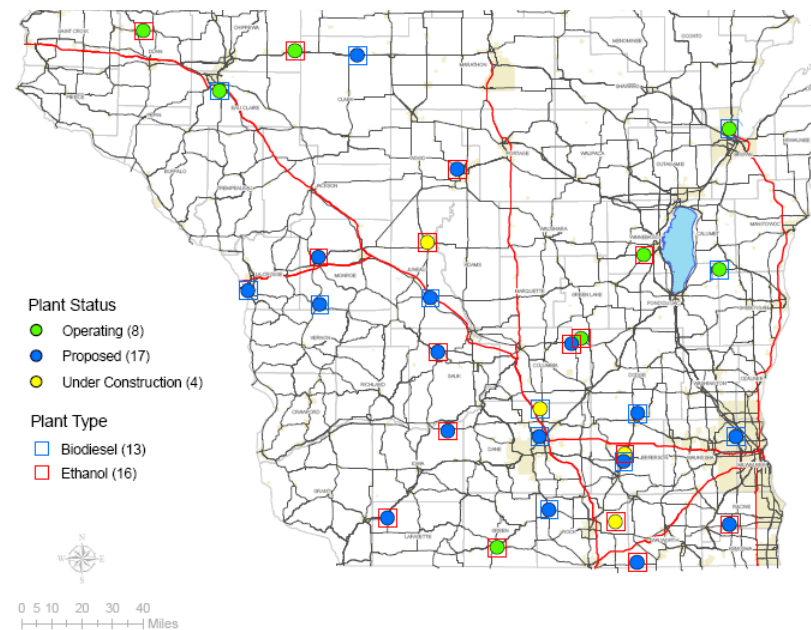
Wisconsin is blessed with excess biomass resources such as corn stover, switchgrass or other prairie grasses, hay, woody materials and manure. These can be converted to ethanol, directly co-fired with coal, gasified or digested for energy. Wisconsin also has a unique manufacturing and resource base that can speed this transformation.⁴

Table 1 below shows that Wisconsin has almost 15 million tons of potential excess biomass. Converting this biomass to ethanol could produce 1.33 billion gallons of fuel per year, half (51%) of the 2.6 billion gallons of gasoline Wisconsin consumed last year. This does not include the 252 million gallons of current corn ethanol production that will increase dramatically. Ethanol does have slightly less energy than gasoline.

Converting this excess biomass to fuel for electric power could displace 15 million tons of coal equivalent, over half (56%) of Wisconsin's current coal use.

These solid and liquid fuel uses are not mutually exclusive since cellulosic ethanol end-products can be dried and burned for power. Biofuel use could also significantly reduce Wisconsin's leading sources of CO2 greenhouse air pollution, coal and gasoline burning.

Wisconsin also has an excellent network of operating and planned ethanol and biodiesel plants (see the WI Department of Agriculture, Trade and Consumer Protection (DATCP) map at right).



⁴ "Biobased Industry in Wisconsin: Technical Report," Energy Center of Wisconsin, Presentation to the Governor's Consortium on Biobased Industry, December 12, 2005.

Table 1: Wisconsin’s Estimated Excess Biomass and Potential Ethanol Production and Coal Displacement⁵

State	Crop Residues	Switchgrass on CRP Lands	Forest Residues	Possible Hybrid Poplars	Primary Mill	Secondary Mill	Urban Wood	Manure	Total Fuel Potential
Biomass (Million Tons/Year)	4.872	3.447	2.217	2.912	1.787	0.076	0.604	0.051	14.76
Potential Coal Displacement (Million Tons/Year)	3.248	2.298	1.478	1.94133	1.19133	0.05067	0.4026	4.36	14.97
Potential Cellulosic Ethanol (Million Gallons/Year)	292.32	206.82	133.02	174.72	107.22	4.56	36.24	372.3	1,327

Biomass use could significantly reduce Wisconsin’s energy dependence, a major government priority.

⁵ From Milbrandt, A., “A Geographic Perspective on the Current Biomass Resource Availability in the United States,” USDOE NREL, 2005, page 50, www.nrel.gov/docs/fy06osti/39181.pdf. We conservatively assume 60 gallons ethanol/ton and 12 million BTUs/dry ton of corn stover, Switchgrass, wood, 20 gallons of ethanol/ton and 4.22 million BTUs/wet pound for manure, and 18 million BTU/ton for Powder River Basin coal. Theoretical ethanol production could be higher. See energy values on page 35. See page 24 for manure potential coal and ethanol assumptions. This chart does not include 332,000 tons of methane but the chart on page 38 does. Some of the Primary Mill Waste may already be utilized.

A 2006 Wisconsin Division of Energy report found:

“Total Wisconsin expenditures for energy increased significantly (19.4 percent) in 2005, setting a new record of almost \$18.5 billion. It is estimated that over two-thirds of Wisconsin’s energy expenditures leave the state’s economy, a significant drain of over \$12 billion, or about \$5,500 per household. This exported state wealth was magnified by higher prices for all fuels in 2005.”⁶ (Emphasis added)

This equates to the loss of 300,000 jobs, with jobs typically paying \$40,000 each on an annual basis.

Increasing biofuel and biopower projects can reduce this job drain by keeping energy expenditures in the state. They also create new high-wage jobs. A typical 40 million gallon Wisconsin ethanol plant creates 32-40 jobs with average annual salaries of over \$40,000 plus health insurance and benefits. UW researchers estimate 3.4 times more total jobs are created from this activity, or at least 141 total jobs. This does not include construction jobs (often a crew of 200 working for 12-18 months). Adding 400 million gallons of ethanol production would create at least 1,410 total jobs⁷. These estimates are considered conservative and would likely be higher for advanced biofuel plants due to the material processing.

UW researchers like Randy Fortenbery are leaders in the biofuel economics field. UW is also applying for a DOE grant for a Great Lakes Bioenergy Research Center (GLBRC) to conduct fundamental, genomics-based research to remove bottlenecks in the biofuel pipeline.

To address advanced biofuels, Governor Doyle appointed the Consortium on Biobased Industry in 2005 to “recommend short-term and long-term policy and commercialization strategies for the Governor outlining overall state goals and actions that promote the development and use of biobased products and bioenergy in an environmentally sound manner,” among other things.⁸

⁶ WI Division of Energy “2006 Wisconsin Energy Statistics,” page 1, www.doa.state.wi.us/pagesubtext_detail.asp?linksubcatid=601&linkcatid=109&linkid=.

⁷ Fortenbery and Deller, “Understanding Community Impacts: A Tool for Evaluating Externalities from Local Bio-Fuels Production,” UW Renk Agribusiness Institute, page 13, www.aae.wisc.edu/renk/library/Biofuel_production_isjext.pdf.

⁸ Executive Order #101, Governor Doyle’s press release, ww.wisgov.state.wi.us/journal_media_detail.asp?locid=19&prid=1168.

In its final report, the Consortium developed a three-pronged strategy to guide its decisions for developing the bioeconomy in Wisconsin:

1. Strengthen Wisconsin's core industries through biobased technologies

Retaining, strengthening and growing existing core industries through bioindustry technology adoption should be a priority strategy. Wisconsin's historically high-value adding agriculture, food and forest products industries can reduce costs and strengthen competitiveness through integration of biorefining technologies.

2. Enhance emerging biobased industries

Wisconsin biobased businesses and emerging industries that incorporate new biobased technologies need continuing support so they can build their market share. Wisconsin's rapidly growing ethanol industry and the market for anaerobic digesters are two such examples. These emerging industries and technologies need a supportive climate of economic development programs, efficient and effective regulatory oversight, and market friendly programs that encourage market building through a variety of mechanisms.

3. Establish leadership in "leapfrog" technologies

Discoveries that leapfrog intermediate processes or existing infrastructure offer the opportunity to develop and commercialize significant new technologies. Developing these technologies requires a strong and fertile research environment coupled with a supportive business climate for transferring those discoveries into commercial products. The research and development capabilities of the University of Wisconsin System are essential resources for establishing and supporting a market leadership position and helping Wisconsin establish itself as a leader in the bioeconomy.⁹

The Consortium also gathered a great deal of useful data that focused on biofuels, biopower and bioproducts. Fuels such as ethanol production have grown to 252 million gallons of production from zero production four years ago.¹⁰

⁹ <http://bioeconomy.wi.gov/docview.asp?docid=8795&locid=72>, page 5.

¹⁰ "Wisconsin Biofuels Facilities Contact List," January 2007 update, <http://power.wisconsin.gov/pdf/BiofuelsFacilitiesContactList013007.pdf>.

In addition the Governor launched the POWER Initiative, Promoting Our Wisconsin Energy Resources, in 2006, saying, “Our state’s energy independence strategy relies on our ability to become a leader in groundbreaking research and developing technologies to make alternative energies more affordable and available to all Wisconsin citizens.”¹¹

Wisconsin is a renewable energy leader in converting wood and manure to energy. Table 2 summarizes state Energy Division information showing that 60% of Wisconsin’s 2005 renewable energy came from wood, mostly burning at paper and power plants for steam and electricity. The growing corn-based ethanol industry is second with 12.8%, followed by existing hydro at 9.6%, and biogas digesters at 6.4%. Wisconsin has 18 methane digesters, more than any other state. Wind and solar make up just 6.3% of the renewable energy sources, about one-tenth of wood’s contribution.¹²

Table 2: 2005 Wisconsin Renewable Energy Use, by Type of Fuel (Trillion BTUs)

Renewable Fuel Type	TBTUs	% of Total
Wood	48.9	60
Ethanol	10.4	12.8
Hydro	7.8	9.6
Biogas	5.2	6.4
Solar	4.1	5.1
Bio-Solid Waste	3.8	4.6
Wind	1.0	1.2
Total	81.1	

We will briefly review the potential for each major alternative in Wisconsin and the policies needed to promote more use. There are four major potential biomass sources in Wisconsin that we will summarize: wood, corn stover, grasses and manure.

¹¹ <http://power.wisconsin.gov>.

¹² WI Division of Energy, “2006 Wisconsin Energy Statistics,” page 60, [www.doa.state.wi.us/pagesubtext_detail.asp?linksubcatid=601&linkcatid=109&linkid=.](http://www.doa.state.wi.us/pagesubtext_detail.asp?linksubcatid=601&linkcatid=109&linkid=)

Scientific Support for Cellulosic Ethanol

Most ethanol today is produced from corn using natural gas as the primary energy source. All credible studies show a positive energy balance to corn ethanol compared to gasoline. A 2006 Science study evaluated six studies and found:

“Studies that reported negative net energy incorrectly ignored coproducts and used some obsolete data. All studies indicated that current corn ethanol technologies are much less petroleum-intensive than gasoline.... Nonetheless, it is already clear that large-scale use of ethanol for fuel will almost certainly require cellulosic technology.”¹³



This peer-reviewed study in the leading journal showed that corn-ethanol is better than gasoline but that cellulosic production from biomass is necessary to move to larger-scale production.

“It is better to use various inputs to grow corn and make ethanol and use that in your cars than it is to use the gasoline and fossil fuels directly,” said Professor Dan Kammen, co-director of the Berkeley Institute of the Environment and co-author of the study.

Cellulosic ethanol from various plant materials like native grasses is even more efficient, another 2006 Science study found.

“Biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials can provide more usable energy, greater greenhouse gas reductions, and less agricultural pollution per hectare than can corn grain ethanol or soybean biodiesel. High-diversity grasslands had increasingly higher bioenergy yields that were 238% greater than monoculture yields after a decade. LIHD biofuels are carbon negative because net ecosystem carbon dioxide sequestration (4.4 megagrams hectare⁻¹ year⁻¹ of carbon dioxide in soil and roots) exceeds fossil carbon dioxide release during biofuel production (0.32 megagram hectare⁻¹ year⁻¹). Moreover, **LIHD biofuels can be produced on agriculturally degraded lands and thus need to neither displace food production nor cause loss of biodiversity via habitat destruction.**”¹⁴ (Emphasis added)

¹³ Farrell, et al, “Ethanol Can Contribute to Energy and Environmental Goals,” Science, January 27, 2006, Vol. 311, page 506. Professor Dan Kammen quote from Science Daily, www.sciencedaily.com/releases/2006/01/060126194250.htm.

¹⁴ Tilman, et al, “Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass,” Science, December 8, 2006, Volume 314, page 1,598, www.sciencemag.org.

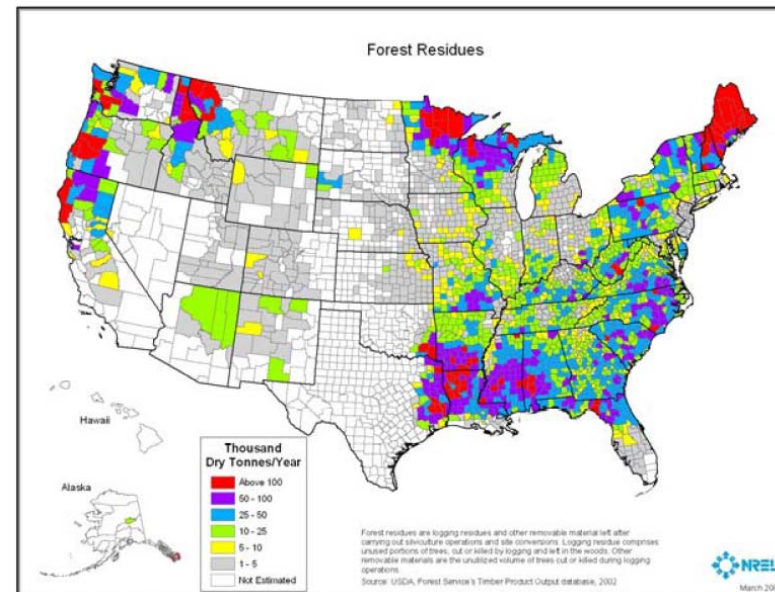
Wood

People have burned wood since the invention of fire. Wood is a high energy fuel and there are large forested areas in Wisconsin with great biomass potential of over 50,000 dry ton per county per year, as this NREL map shows. Wood has other advantages:

1. Produces 90-95% less net CO₂ than coal;
2. Trees can fix up to 6 tons of CO₂ per acre per year worth up to \$22 in carbon credits on the Chicago Climate Exchange;
3. Is a renewable fuel that grows relatively quickly;
4. Produces low sulfur, NO_x, and mercury air emissions; and
5. Is low in ash, typically less than 1%.

More important, Wisconsin is a national leader in wood-fired boilers with more than 70 megawatts (MW) of wood electricity production, according to the Wisconsin Public Service Commission.¹⁵ In 2005, Wisconsin electric utilities used 253,638 tons of wood to create 2,961 billion BTUs of energy, mostly for electricity. Much of that was produced by Northern States Power's Ashland Bayfront Plant and La Crosse's French Island facility.¹⁶ This shows potential cellulosic biofuel producers that there is a market and way to deliver large amounts of biofuels for energy production. Both plants have the capacity to burn more wood.

Wisconsin also has a great resource with the USDA Forest Products Lab in Madison. Researchers John Zerbe and Richard Bergman wrote the "Primer on Wood Biomass for Energy," which observed:



¹⁵ WI Public Service Commission, "Strategic Energy Assessment," 2007, page 43, http://psc.wi.gov/apps/erf_share/view/viewdoc.aspx?docid=69877.

¹⁶ WI Division of Energy, "2006 Wisconsin Energy Statistics," Page 64, www.doa.state.wi.us/docs_view2.asp?docid=770.

1. Haul distances of more than 50 miles are not usually economical;
2. Woodchips cost \$2.50 per million BTUs, one-eighth the cost of electricity and one-half the cost of natural gas; and
3. Extraction (removing wood from the forest site) is a major cost as well as for transportation to the plant. There are new techniques being considered to cut down on this cost, for example, a modified cable harvest system used in the West might be applied to the steep lands.

Wisconsin hardwood oaks, maples and hickories have a high fuel value of about 9,500 BTUs per dry pound.¹⁷ Hybrid Poplars have an energy content of 8,431 BTUs per pound and 1.57% ash content.¹⁸ More specific analysis is needed on local forest types and actual BTU values to determine the market near proposed plants and how this compares with coal prices.

Co-firing will likely be the most cost-effective path to cellulosic ethanol production whereby the power plant is heated with wood, grass or other biofuels. A 2004 Forest Products Lab report found:

“Co-firing refers to the practice of introducing biomass as a supplementary energy source in coal plants. It is a near-term, low-cost option for using woody residue, costing approximately \$0.02 per kWh while reducing pollutants. According to the U.S. Department of Energy, 20 electric utilities are co-firing biomass with coal. Extensive demonstrations and trials have shown that effective substitutions of biomass energy can be made from 10% to 15% of the total energy input. Investments are expected to be \$100 to \$700 per kW of biomass capacity, with the average ranging from \$180 to \$200 per kW. **Co-firing results in a net reduction**



¹⁷ “How to Estimate Recoverable Heat Value in Wood and Bark Fuels,” USDA Forest Products Lab, 1987, www.fpl.fs.fed.us/documnts/fplgtr/fplgtr29.pdf.

¹⁸ US Department of Energy, Biomass Feedstock Composition and Property Database, www.eere.energy.gov/biomass/progs/search1.cgi.

in greenhouse gases and lower emissions of sulfur dioxide and nitrogen oxides.”¹⁹ (Emphasis added)

In fact, the Alabama Renewable Energy Alliance plans to build the first wood-fired ethanol plant in the country in Dadeville. It will co-generate 13 MW of renewable electricity and produce 50 million gallons of ethanol a year. This will lower the plant’s energy costs as natural gas bills are often more than \$10 million a year. (I am a consultant on this project.)

The Forest Products Lab researchers also discussed wood-power economics below.

Wood Economics

“The price of wood for use as fuel is extremely variable. Sometimes when there are surplus supplies of wood residues at forest products manufacturing plants or municipal solid-waste handling facilities, the cost can be very low or even negative. In these situations, the cost of wood fuel is minimal, mainly transportation charges for delivering from the supply site to the wood combustion or wood-processing unit.

“At other times, the cost of wood fuel at a plant may be quite large since large volumes of fuel are needed to have a dependable and consistent supply of wood fuel if competing with a paper mill. However, wood power plants can find and do maintain a fairly low price and consistent fuel supply when adequate quantities are available....The principal economic advantage of wood-chip systems is that wood fuel is usually considerably less expensive than competing fossil fuels.”

The Forest Products Lab’s focus is shifting to producing fuel from cellulose, a recent Wisconsin State Journal story reported. “The push for ethanol production hasn’t gone unnoticed at the U.S. Forest Products Laboratory headquarters in Madison. The main source of this biofuel has been corn, but some in Wisconsin see great potential for another source. At the Forest Products Laboratory, Director Chris Risbrudt is leading an initiative to find a profitable process that will take advantage of Wisconsin’s heavily forested landscape and the paper industry to turn wood products into cellulosic ethanol.”²⁰

¹⁹ “Wood Biomass for Energy,” USDA Forest Products Laboratory, 2004, www.fpl.fs.fed.us/documnts/techline/wood-biomass-for-energy.pdf.

²⁰ Nathan Leaf, “Working On Ethanol, Forest Products Lab’s Idea Would Be To Turn Wood Products into the Fuel,” Wisconsin State Journal, February 18, 2007, www.madison.com/archives/read.php?ref=/wsj/2007/02/18/0702170210.php.

The “Forest Biorefinery and Biomass Utilization: A Roadmap for Research at the USDA Forest Products Laboratory” in 2006 found:

The Forest Products Laboratory (FPL) is well-placed to scientifically support three national goals:

1. Reduce fire hazards presented by over-stocked forest land,
2. Reduce dependence on crude oil imports, and
3. Reduce the production of greenhouse gases.

All three goals can be met by developing economically viable biorefineries. Building on a long history of handling and treating wood, FPL experts in wood structure, microbiology, enzyme technology, chemical engineering and economics will work together to overcome the hurdles in the path to biorefinery commercialization. Some of these hurdles include developing fermentation of five-carbon sugars, improving access to cellulose, obtaining products from lignin, and separating components in pyrolysis oils. Furthermore, as new processes emerge from this research, engineering and economic analysis will be used to present compelling business cases for transfer to industrial partners.”



Wisconsin DNR estimates that invasive Buckthorn infests 570,000 acres. These and other invasive species like honeysuckle and cedars could be removed and burned for biofuels.²¹ Clearly Wisconsin has many resources in both fuel and people to take full advantage of wood for biofuels. More research and funding are needed to develop pilot-scale plants.

²¹ WDNR, “What is an Invasive Species,” <http://dnr.wi.gov/org/land/forestry/Publications/pdf/InvasivePlantStudy.pdf> and <http://invasivespecies.wi.gov/awareness/category.asp?linkcatid=848&linkid=327&locid=63>.

Corn Stover

Corn stover and other crop residues are estimated at 4.4 million dry tons from Wisconsin's 4 million acres of corn.²² *Zea mays* (corn) stalks and leaves without cobs have an energy content of 7,325 BTUs per dry pound with 11% ash.²³

A 2003 National Renewable Energy Lab study found:

“Corn stover, the material remaining on the surface after the grain is collected, is the largest underutilized crop in the U.S. (emphasis added). About 250 million dry tons (dt), is grown annually, triple the amount 50 years ago. Removing the excess after soil erosion needs are met can reduce the need to till, increase farmer income and provide 100 million dt or more for the production of fuels, chemicals and materials.



For corn stover feedstock to become a reality for large biorefineries, innovations are needed between the field and delivery to the processor in three areas - collection, storage and transportation.

Present studies focus on collecting and baling dry material following the grain harvest, after the stover has field dried from 60-70% moisture to less than 30%. The collection radius has typically been limited to 50 miles due to the transportation cost of the bulky material. The biomass processing plant is envisaged to maintain a two-week inventory on site, with bales trucked to the plant throughout the year. This system offers many areas for improvement.

To reduce collection delays and increase density, feedstock drying and densification methods are being investigated. This approach is appropriate when a dry, compacted material is desired for processes such as gasification and co-firing. However, these operations increase cost from \$35 per dt to \$50 per dt or more, and densification inhibits wet processing. Pellets need to be

²² www.nrel.gov/docs/fy06osti/39181.pdf.

²³ www.eere.energy.gov/biomass/progs/search3.cgi?25864.

‘reconstituted’ by soaking in water to shorten digestion time for hydrolysis — the Sugar Platform for production of fuels, chemicals and materials.

One-pass harvest of both grain and stover, wet storage and rail transport to the processor appear to be advantageous, with a delivered cost of \$30 per dt while returning more than \$30 per acre net income to the farmer. The relative difference in net income between one-pass harvest and baling to the farmer...nets the grower \$22 to \$47 per acre depending on the yield... Table B, baling, nets \$16 to \$22 per acre to the farmer for one collection site with the same collection area, 1.5 million acres with more than 1 million dry ton supply.²⁴



Much of this paper focuses on how stover collection would benefit farmers and needs to make this practical. One study on co-locating a corn stover ethanol plant next to a coal plant found the price of delivered stover to be \$33.86-38.62 per dry ton. This study is also explored using co-generated waste heat to drive the ethanol plant. A 70 million gallon per year plant had an internal rate of return of 10.7-29.3% on \$130 million invested.²⁵

To test collecting and storing stover, a large-scale corn stover collection project is described based on the 1996 experiences of the Kearney Area Ag Producers Alliance (KAAPA). Over 4,000 mostly irrigated high yielding acres of cornstalks were baled in a three-month period as a demonstration for a proposed corn stover to paper pulp project. A large quantity of these bales was stored for 18 months.

This project was a demonstration to generate equity investment, alleviate both producer and processor concerns, generate realistic cost estimates and advance the collection, storage and transport learning curve. The dirt removal strategies and improved baling processes developed were superior to prior collection methods.

²⁴“Innovative Methods for Corn Stover Collecting, Handling, Storing, and Transporting,”
www.nrel.gov/docs/fy04osti/33893.pdf.

²⁵ “Feasibility Study for Bioethanol Co-Location with a Coal Fired Power Plant: November 29, 2001 - July 28, 2002,”
www.nrel.gov/biotechsymp25/docs/abst1a-06.doc.

Strategies for various types of cropping and minimum tillage practices were developed as well to provide ground cover to minimize and prevent soil erosion.

Precautions needed to insure that collected stover bales remained in good condition at the end of the storage period were determined, along with the weather risks and the critical parts of the process that need to be fine-tuned to make sure it is reliable, efficient, sustainable, functional and economic.”²⁶

Excess corn stover represents a major potential resource in Wisconsin and pilot-scale stover biofuel plants are needed to realize that potential. As the photo below shows, there is a lot of potential fuel left on the ground.



²⁶ US DOE, NREL, “Corn Stover Feedstock Learnings: Kearney Area Ag Producers Alliance Removal Project,” www.nrel.gov/biotechnsymp25/docs/abst1a-06.doc.

Grasses

Much of Wisconsin and the Midwest were originally covered with tallgrass prairies made up of switchgrass, big bluestem, indiangrass and many other grasses and flowers. Switchgrass has an energy content of about 8,000 BTUs per dry pound and 5.76% ash content.²⁷

Interest has increased since President Bush mentioned switchgrass as a possible energy source in the 2006 State of the Union speech.

Burning prairie grass like switchgrass with coal or digesting for ethanol provides a renewable and cleaner alternative energy source. Co-firing coal burning energy plants replace some coal with grasses and biomass from energy farms. Using switchgrass, prairie grasses or other cellulose for ethanol is four times more energy efficient than gasoline based fuels if the process can be economical.²⁸



Adding a renewable source of fuel reduces air and water pollution, restores crucial habitat and provides farmers with a high-demand cash crop.

The clearest path to cellulosic grass ethanol is likely burning grasses to fire an ethanol plant. Co-firing prairie grass with coal reduces NO_x, soot and CO₂ air emissions from coal power plants.

²⁷ <http://www.eere.energy.gov/biomass/progs/search1.cgi>.

²⁸ Hammerschlag, Roel, "Ethanol's Energy Return on Investment: A Survey of the Literature 1990-Present," Environmental Science Technology, ASAP Article 10.1021/es052024h S0013-936X (05)02024-9, February 8, 2006.

A University of Wisconsin study found that burning 10% prairie grass with coal in a 50 MW pulverized coal boiler:

- Reduced nitrogen oxide (NO_x) pollution by 20-31%;²⁹
- Reduced soot particulate matter (PM) pollution measured as opacity by 50-60%;³⁰ and
- Reduced greenhouse gases by 9% since grasses recycle atmospheric carbon, there would be no net increase in carbon dioxide production. The carbon released by burning the grasses is the carbon the grasses absorbed from the atmosphere in the last year.

In addition, burning switchgrass and other prairie grasses for bioenergy creates demand for the popular Conservation Reserve Program, which now has 36 million acres enrolled. Prairie grasslands prevent soil erosion and reduce polluted runoff by up to 75%. Native prairie grasses filter strips act like coffee filters to strain out pollutants and absorb nutrients.³¹ Prairies grasslands can reduce 100-year floods by up to 10% and up to 39% if combined with other practices like conservation tillage and upland flood storage, according to USDA estimates.³²

It can also help restore native grassland habitats; more than 90% of North American's tallgrass prairie has been lost, according to the Nature Conservancy.³³ Prairies provide good wildlife and bird habitat for declining migratory songbird species. But grasses should be cut after nesting season to protect nesting birds and chicks. Because different bird species prefer different conditions, both harvested and unharvested fields should be left for habitat.¹⁶

Prairies could give Wisconsin farmers another crop and income source of \$120-180 per acre for 4-6 dry tons of grass production at \$30 per dry ton. Another advantage is that grasses use existing hay balers to harvest for the power or ethanol plants.

²⁹ Aerts, D.J., Bryden, K.M., Hoerning, J.M., Ragland, K.W. Department of Mechanical Engineering, University of Wisconsin-Madison, "Co-Firing Switchgrass in a 50 MW Pulverized Coal Boiler," 1997.

³⁰ UW-Madison College of Agriculture and Life Sciences, Center for Integrated Agricultural Systems, Research Brief #51, "Switchgrass Production for Biomass," 2001. Summary at www.cals.wisc.edu/media/news/07_97/switchgrass_biomass.html.

³¹ USDA NRCS website at www.nrcs.usda.gov/feature/buffers.

³² Interagency Floodplain Management Review Committee to the Administration Floodplain Management Taskforce, "Sharing the Challenge: Floodplain Management into the 21st Century," Washington, D.C., 1994, p. 157.

³³ www.nature.org/wherewework/northamerica/states/oklahoma/preserves/tallgrass.html.

And it helps electric utilities meet clean air standards with less expensive control equipment, and reduces greenhouse air pollution from a large CO2 source. A dry ton of switchgrass has about 16 million BTUs per dry pound,³⁴ 90% as much energy as a ton of coal, but burns much cleaner. One acre of prairie grass cut once per year can offset about 3.5 tons of coal based on our analysis (see Table 3), which shows the yield rate of four tons per acre per year depending on seed type, soils and climate, equivalent to 240 gallons of ethanol.

Table 3: Switchgrass Yields and Fuel Conversions

Fuel Source	Energy Content (MBTUs/Dry Ton)	Potential Production (Tons/Acre/Year)	Total Potential Energy (MBTU's/Acre)	Potential Ethanol (Gallons/Acre)	Coal Equivalent (Tons/Acre/Year)
Switchgrass	16	4	64	240	3.5

This assumes 60 gallons of ethanol per ton of grass and four dry tons per acre compared to 18 million BTUs per ton for Powder River Basin coal.

Farm Bill Policy Opportunity

Congress is now working on the 2007 Farm Bill and considering creating an Energy Reserve Program to expand the current Conservation Reserve Program energy option. Adding 10-20 million acres for energy crops could produce up to 320-3,840 quadrillion BTU's of clean energy, equivalent to 22.5-270 million tons of coal. The cost: would be \$20-40 per acre or \$2-8 billion per year total to taxpayers, but farmers could earn up to \$9.6 billion for energy crops. Wisconsin has high potential for switchgrass and hybrid poplars on set aside farm land in the CRP program. Table 4 shows the estimated potential state tonnage, as indicated in a 2005 DOE report.³⁵

³⁴ US Department of Energy, Biomass Feedstock Composition and Property Database, www.eere.energy.gov/biomass/progs/search1.cgi.

³⁵Milbrand, A., "A Geographic Perspective on the Current Biomass Resource Availability in the United States," 2005, page 41, www.nrel.gov/docs/fy06osti/39181.pdf, assumes 8,000 BTU/pound for Switchgrass, and 9,000 BTU/pound for coal and poplars.

Table 4: Potential Fuel from Wisconsin Switchgrass and Hybrid Poplars

Crop	Potential Fuel (Dry Tons/Year)	Potential Ethanol Production³⁶	Tons of Coal Displaced
Switchgrass	3,447,000	206,820,000	2,295,702
Hybrid Poplars	3,203,000	192,180,000	2,133,198
Total	6,650,000	399,000,000	4,428,900

By comparison, Wisconsin produced about 252 million gallons of ethanol exclusively from corn in 2006. Adding grass and tree production could more than double 2006 production.

Wisconsin used 26.7 million tons of coal in 2006, according to the U.S. Energy Information Agency.³⁷ Table 4 shows that Wisconsin could displace about one-sixth of its coal production with switchgrass and hybrid poplars alone.

While these are large numbers, remember that the material left over from the ethanol process can be dried using waste heat and burned for fuel, so this is not an either-or choice.

Also a diverse, low input prairie ecosystem used for ethanol production can store 13.75 times more CO₂ than is used to produce ethanol from the feedstock used, according to Tilman's 2006 Science study.

More pilot projects are needed to fully develop this option.

³⁶ Assumes 60 gallons ethanol/ton for Switchgrass and for wood, which is conservative for both.

³⁷ Wisconsin State Energy Profile, http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=WI.

Manure — Got Fuel?

Manure is one of the oldest fuels and is plentiful in Wisconsin thanks to the 1.2 million dairy and 3.4 million total cattle. Each cow produces about 85 pounds of manure a day, or 31,000 pounds annually. Table 5 shows the Wisconsin dairy herd has a potential fuel tonnage of 18.6 million tons with over 78 trillion BTUs, enough to displace over 4 million tons of coal if burned for electricity. If converted to ethanol at 20 gallons per ton, it could produce 372 million gallons, more than doubling current production. The 2005 NREL study estimates Wisconsin's manure resources are only 51,000 tons per year. Our estimates are much higher.

Using excess manure for fuel would reduce many water quality challenges from the nutrients that manure contains. There are challenges drying and transportation the material, which require additional study and tests.



Table 5: Wisconsin's Potential Manure Power

State	Dairy Cows in 2006	Annual Manure Production (Million Tons)	Manure Energy Content (Trillion BTUs)	Tons Coal Displaced (Million Tons)	Potential Ethanol (Million Gallons)
Wisconsin	1.2 million	18.6	78.5	4.36	372

We assume an average dairy cow produces 85 lbs. of raw manure a day per 1000 pounds of animal weight. 85 lbs. of manure/day x 365 days = 31,025 lbs. manure/cow/year x 1.2 million cows = 37.2 billion pounds or 18.6 million tons of manure/year. Dairy manure averages 2,110 BTU per wet pound at 87.5% moisture or 4.22 million BTUs/ton manure x 18.6 million tons

manure/year = 78.5 trillion BTUs/year of potential dairy cow manure energy. A ton of Powder River Basin coal has 18 million BTUs, so that comes to 4.36 million tons of coal equivalent if converted to power. We conservatively assume 20 gallons/ton of ethanol production for manure or one-third the production of grass and corn ethanol because wet manure has one-third the energy content. The 18.6 million tons could produce 372 million gallons of ethanol if this process can be developed and deployed.

The dairy manure assumption may be high since some cattle are on pasture and the manure is not available. But it may also be low because there are 3.4 million cattle in Wisconsin. We also assume all manure is wet, though some may be dry with higher energy content.

One 2003 DOE study showed dairy manure had cellulose and hemicellulose levels of 39.6% and recovery rates of 34% more sugar from manure than softwood. More research and a pilot plant are needed to realize the full potential of manure-based ethanol production.³⁸

As dairy operations grow larger, many operations are having real difficulty finding enough land to safely spread manure for nutrient management. The use of this excess manure to produce biopower would be very attractive to these farms. The challenge is to fully use manure for digesters, manure ethanol, then burn it for power.

Potential Advanced Biofuel Projects in Wisconsin

Currently Wisconsin has 252 million gallons of corn-based ethanol production expected to grow to 605 million gallons by 2010. DATCP estimates that paper-based ethanol will grow to 183 million gallons by 2010 and biodiesel production to 115 million gallons.³⁹ Even with these new technologies, many existing ethanol and power companies are planning progress with advanced biofuels, some that use biomass.

³⁸ Chen, et al, "Value-Added Chemicals from Animal Manure, Final Technical Report," USDOE Battelle Lab, 2003, pages 5, 24.

³⁹ WI DATCP, "Biofuels: Current Production and Potential," 2007.

ACE Ethanol in Stanley

ACE Ethanol in Stanley is studying a circulating fluidized bed boiler to burn syrup and biomass to power their plant. They are applying for state and federal grants to make this technology work for the first time in Wisconsin. It should be noted that I am working with their affiliate, Integrated Bio-Technology, to build a wood-fired biorefinery in Alabama.

Renew Energy

Renew Energy's plant in Utica near Oshkosh is currently testing biogas digesters for the distillers' grain to get methane to help fire their plant. Results are encouraging. Renew's Jefferson plant is the first plant built in Wisconsin to use fractionation, which separates the corn start from the germ, bran and oil, reducing water and energy needs by one-third. That plant is slated to go into production later this year. They are also a client of mine.

There are many plans to employ advanced ethanol and biofuels techniques at new plants. We have a brief summary of several below.

Park Falls

The Flambeau Paper Company in Park Falls plans to use an innovative technology to make 20 million gallons of ethanol, fuel from wood and produce pulp for the paper industry. In order to make this work, they are requesting a grant from the state and federal governments to open this shuttered mill. They are requesting \$80 million from the U.S. Department of Energy.⁴⁰ Their first phase is to fire the plant with wood, then produce ethanol as a second step. They estimate they can make ethanol for \$0.50 per gallon, half the cost of traditional corn-based ethanol.

Flambeau Paper is working with CleanTech Partners. Considering the importance of biorefinery for the pulp and the paper and agricultural



⁴⁰ "Reopening Flambeau River Paper Targets Energy Independence," paper 360, December 2006, page 13.

industry, it will take a well-coordinated effort to get biorefinery commercialized by 2010. CleanTech Partners is coordinating this effort with the Biorefinery Deployment Collaborative.⁴¹

Belmont Bio-Ag

Belmont Bio-Ag, LLC is located in the original capital, Belmont, and grew out of the desires of the farming community to do things differently. With U.S. Hwy. 151 bypassing Belmont and grain farms replacing the dairy and beef operations, community members knew they needed something new that could bring the future of agriculture to their community.

In 2002, a group of local people got together and imagined different ways to create markets for local agricultural products like corn, steers and biomass. They knew that there were problems with livestock facilities and distributed power generation, and questioned if they could do better if they combined them. What would happen if they started from the position that doing the right thing for the environment, rather than a burdensome afterthought, became the core of the business?

Belmont Bio-Ag is a first of its kind, environmentally inspired agricultural campus design integrating horticultural greenhouses, ethanol production, cattle finishing and electricity generation into one system called Symbiosys.^{TM 42} They plan to make a public offering later this year.

C 5-6 Technologies Makes Ethanol Better

C 5-6 Technologies is a new Middleton company working to increase energy independence and reduce global warming with enzyme technology that increases corn ethanol efficiency and facilitates ethanol production from other feedstocks such as soy meal and cellulosic biomass. C 5-6's corn ethanol development program is targeted to improve existing corn-based ethanol production by up to 10%, which would increase national ethanol production by 660 million gallons or save existing producers nearly \$1 billion in corn and energy costs.



⁴¹ For more information, contact Masood Akhtar, President, CleanTech Partners, 608-203-0111, www.cleantechpartners.org.

⁴² Belmont Bio-Ag website, www.belmontbioag.com/community.html.

Making ethanol from soybeans would relieve some of the corn price pressure and has the potential to increase ethanol production by two billion gallons in the U.S. alone. C 5-6 Technologies' soy process uses the meal portion of the soybean, providing more oil for biodiesel production. C 5-6 Technologies was spun off of the Lucigen Corporation in August 2006. Lucigen, founded by David Mead, Ph.D. in 1998, develops tools for molecular biology. C 5-6 is currently raising equity funding to complete its technology developments and commercialize its biofuels enzymes.⁴³ They are also one of my clients.

CowPower Plant Up and Running

Manure is a major challenge to dairy farmers, but is also a major potential energy source, as discussed earlier in this report. The Elimanure® prototype is working on the 3,700 animal unit Wiese Brothers dairy farm near Green Bay with a renewable electricity generation target of about 600kW. The farm used about 4,500 semi-tank truck trips per year to haul and spread manure, an expensive and challenging endeavor. Cows also need 66% more land for manure than for feed, driving farmers to secure more acreage than is needed for dairy animals.

Elimanure® collects manure directly from the animal barn, keeping it aerobic and odorless. The manure is put in a Bio-Dryer to reduce moisture from about 12% solids to about 60% solids, a carbon rich fuel material that is an odorless, pathogen free solid that looks and feels like peat moss. The fuel is burned in a Biomass boiler, creating steam that turns a turbine to make electricity. The waste heat dries the incoming manure. This process is the first in the world to successfully burn manure to compete combustion. The ash from the boiler is less than 2% of the incoming liquid, which contains phosphorous, potassium and is granular 0-8-10 fertilizer, which can be spread back on the land more easily than liquid waste.⁴⁴



⁴³ For more information, contact John Biondi, President, C 5-6 Technologies, 608-836-3587 x321, jbiondi@c56technologies.com.

⁴⁴ For more information, contact Paul Schneider, President, Skill Associates, 920-759-9223, pschneider@BurnManure.com.

Alliant Energy's Cassville Plant Expansion Could Burn Biomass

Alliant Energy has been testing switchgrass biopower with a 10-year burn project at their Ottumwa, Iowa facility (see full story below). The utility has proposed a Nelson Dewey power plant expansion that would use a circulating fluidized bed to burn switchgrass, wood or corn stover in addition to coal and pet coke. There are large biofuel stocks near the plant. (I am working for Alliant on a biofuels feasibility study on this project.) The challenge is to collect, deliver and store the material in a way that burns successfully and displaces coal at this and other power plants.

Successful Grass Test Burn in Iowa

The challenge of biofuels was shown in the 2007 story, "Farmers Convert Switchgrass to Electric Power" from Iowa Public Televisions' "Market to Market" program. Alliant's Ottumwa switchgrass test is included in its entirety to show the importance of grants to make biofuels projects a reality. This project is the largest scale test of switchgrass co-firing in the country.⁴⁵

As stated in the program, "The campaign to reduce global warming is, if you'll pardon the expression, heating up.

While most environmental issues seem to have a polarizing effect, the issue is transcending traditional political and social boundaries and creating a few strange bedfellows in the process.

It seems that everyone from former Vice President Al Gore to evangelical Christian writer Rick Warren is trying to get Americans to respond to "the inconvenient truth" of global warming.

Even those targeted as key emitters of CO₂, like power plants, are looking for ways to reduce or sequester their emissions.

One innovative project is attempting to replace a portion of its coal with cleaner-burning switchgrass. David Miller reports on the Midwestern farmers who are betting their grasses on energy.



⁴⁵ Aired February 11, 2007, <http://www.iptv.org/mtom/feature.cfm?Fid=394>.

The connection between southern Iowa farmland and a coal-fired power plant would appear to be remote but the link between the two can be found in the power plant's fuel. Three times over the past six years, Alliant Energy, the region's electrical power provider, has replaced a small portion of the coal burned at its Ottumwa Generating Station in Chillicothe, Iowa with switchgrass.

The roots of this idea go back to the early 90s when members of the Chariton Valley Resource Conservation and Development group began looking for one more way to improve water quality in nearby Rathbun Lake, an Army Corps of Engineers flood control and recreational reservoir. After some research they decided growing switchgrass for power was a good solution. Besides being a renewable resource, the hearty prairie plant would hold back soil, filter water and absorb carbon.

Bill Belden, Biomass Project Manager, Chariton Valley RC&D, said: "I'm proud of the fact that there was enough support by producers in the area to try to grow a crop for a project they had no clue whether it would be successful but they liked the concept."

The RC&D partnered with the U.S. Department of Agriculture, the U.S. Department of Energy and Alliant Energy. Together, \$38 million in grants and matching funds were raised for the project. In 1996, they received their first grant and went to work.

Kim Zuhlke, Vice President, New Energy Resources, Alliant Energy, said: "I think one of the things we were going to need in order for this to occur, we were going to have to have a very strong local interest, a very strong grower group, because you've got really a chicken and an egg sort of problem here. It's sort of like if you don't have the fuel then why even bother talking about it. If you have the fuel will it work in this sort of application?"

It was unknown what effect burning switchgrass would have on the plant's multi-million-dollar boiler. The loss of the boiler would directly affect a portion of Alliant's more than one million customers that are spread across Iowa, Minnesota, Wisconsin and Illinois.

Alliant, along with MidAmerican Energy, the region's other electric power company as well as part owner of the generating station, had to determine how much coal could be safely replaced with switchgrass. The consensus was five percent. The experiment turned out to be the largest of its kind in the world.

Alliant's Zuhlke added: " We know that there's a lot of interest nationwide in increasing the amount of our energy that comes into our mix from renewables and there is interest in consumers saying yes, I want you to increase that mix of renewables and we have some consumers say, not only do I want you to increase that mix, I'm willing to pay a little bit more if it is renewable."

To make enough fuel readily available, 72 farmers agreed to plant switchgrass on 4,000 of their Conservation Reserve Program acres near the Ottumwa Generating Station. To make the idea more palatable to the U.S. government, the participating farmers would not be compensated for any switchgrass harvested off those CRP acres.

By 1999, the first crop was ready to be harvested. At first, the product was rolled into round bales, but to avoid a transportation permit issue it was decided square bales would be needed. The RC&D had a machine specially designed and built to make large square bales.

Doug Goben, switchgrass grower and RC&D member, was at the wheel of the baler on the first day of harvest in 1999. He said: "It was more of, you know, I hope it works, I hope we do not cause any problems with the power company.... It was just something new, you know, and the potential of putting implement dealers back in business, putting implements back on the lots out here and farmers buying the implements, buying repairs, buying fuel, you know, in our local community because we're losing people in our local communities every day. I'd like to see them come back."



Once the product is baled, it's sent to one of 20 specially built storage buildings or delivered directly to a one-of-a-kind processing facility attached to the Ottumwa Generating Station.

Bill Belden, Biomass Project Manager, Chariton Valley RC&D, said: "We realized that that is the lowest value we probably can attain from a biomass crop like switchgrass, cutting it, harvesting it, burning it. There are other technologies that are now starting to loom on the horizon: ethanol production, polymer production, plastics, fiberboard, who knows what the creative mind of our scientists will come up with next."

Three test burns were conducted — the last one was completed in May 2006. During that 71-day period, a little more than 15,600 tons of locally grown Switchgrass was used to replace 12 thousand tons of coal. Alliant officials estimate 51 thousand fewer tons of carbon dioxide were emitted and enough energy was produced to power 1,900 homes.

But even if the results indicate it is safe to use switchgrass on a long-term basis, more questions remain to be answered. Are there enough farmers to grow the estimated 200,000 tons needed each year? Is there enough suitable land within a short distance of the power plant? And most important, can the players find a way to make today's experiment into tomorrow's reality in an economically viable way for both Alliant and the farmers?

According to Alliant's Zuhlke: "There is interest in consumers saying yes, I want you to increase that mix of renewables and we have some consumers say, not only do I want you to increase that mix, I'm willing to pay a little bit more if it is renewable."

And Goben is still hopeful the project will have a positive outcome. He said: "I think once we learn how to adapt and get the plant to adapt I think we can increase yields, we can increase other aspects of it that will make it profitable, I think it will happen, that's the hard part. We're through the easy part, growing it and putting it in the package. The hard part is coming now is how we make the business work.'"

Environmental Issues with Biomass Removal

Here are some possible positive biomass energy scenarios:

1. Planting buffer strips near streams and waterways for biomass production and water quality improvements;
2. Managing forests to thin unwanted trees for energy production;
3. Promoting mixed prairies to increase biofuel production;
4. Using excess mill waste, corn stover and grass production to create fuel; and
5. Removing invasive species like Buckthorn, Honeysuckle and Reed Canary Grass for biomass production.

Using excess biomass, wood, and corn stover for fuel requires proper conservation practices to prevent a potential for increased runoff from exposed soil and loss of forest habitat. Added soil conservation measures such as grass buffer strips, conservation tillage, crop rotations and precision farming, other appropriate soil conservation practices, and proper timber management can prevent these problems. Forest concerns are mitigated by only using excess production and wood waste, especially urban waste. There is also concern that increased corn stover use could increase erosion and the size of the hypoxic zone in the Gulf of Mexico, but the National Renewable Energy Lab study found:

“Careful farming practices that limit the fertilizer addition to just that amount deemed necessary from quantitative soil analysis would probably be sufficient to further reduce the nutrient loads to surface water bodies to levels acceptable from a hypoxia standpoint in most years.”⁴⁶

This also mitigates concerns from increased corn production due to ethanol use. Some stover removal reduces nitrogen fertilizer needs, makes no-till farming easier, and leads to quicker soil warming, especially in northern climates like Wisconsin. Exposed biomass and stover are also converted to CO₂ by bacteria. To thoroughly address these concerns, we need to consult local conservationists, foresters and farm conservation plans to ensure soil erosion does not increase with biomass removal. These risks also need to be weighed against the environmental costs of coal mining and oil drilling. For more information, see the DOE fact sheet “Energy Crops and the Environment” and the USDA research paper on this topic.⁴⁷

Carbon Reduction and Credits

Biomass could displace up to half of Wisconsin’s coal or about half its gasoline, the two largest sources of CO₂ according to a 2004 Wisconsin DNR study.⁴⁸ Burning biomass instead of 15 million tons of coal could reduce CO₂ emissions by 45 million tons per year. Burning 1.3 billion gallons of ethanol could displace 1.1 billion gallons of gasoline use, reducing CO₂ emissions by 11 million tons per year. Biomass is a very cost-effective way to reduce CO₂, according to a recent study.

A 2003 Environmental Science and Technology study found:

“Cofiring biomass with coal in existing power plants offers a relatively inexpensive and efficient option for increasing near-term biomass energy utilization. Potential benefits include reduced emissions of carbon dioxide, sulfur,



⁴⁶ US DOE NREL, “Quantifying Cradle-to-Farm Gate Life Cycle Impacts Associated with Fertilizer Used for Corn, Soybean and Stover Production,” 2005, page 87, <http://www.nrel.gov/docs/fy05osti/37500.pdf>.

⁴⁷ USDA, Crop Residue Removal for Biomass Energy Production, 2006, http://soils.usda.gov/sqi/management/files/AgForum_Residue_White_Paper.pdf, and <http://bioenergy.ornl.gov/main.aspx>.

⁴⁸ WI DNR, “Wisconsin Greenhouse Gas Emission, Trends from 1990 to 2000,” 2004, page 2, <http://dnr.wi.gov/org/aw/air/GLOBAL/GHGinventorytext.pdf>.

and nitrogen oxides and development of biomass energy markets.... Except at low biomass prices (less than \$15 per ton), cofiring is unlikely to be competitive for NO_x or SO_x control, but it can provide comparatively inexpensive control of CO₂ emissions: we estimate that emissions reductions of 100 Mt-CO₂/year (a 5% reduction in electric-sector emissions) can be achieved at 25 ± 20 \$/tC. **The 2-3 year time horizon for deployment-compared with 10-20 years for other CO₂ mitigation options-makes cofiring particularly attractive.**⁴⁹ (Emphasis added)

In addition to displacing coal and gasoline with biomass, there are added carbon sequestration credits from the land conservation practices. Prairie ethanol sequesters 14 times more CO₂ than it burns. Biomass fuel costs of \$30 per ton could be competitive with \$20 coal if we include carbon credits for the conservation practices. There are also credits for methane destruction from manure since methane is 20 times worse than CO₂ for global warming. The National and Wisconsin Farmers' Union and Iowa Farm Bureau are currently enrolling farmers in the Chicago Climate Exchange for no-till, grass and forest practices.

Heat Content of Various Fuels

The fundamental challenge is converting cellulosic biomass energy into either liquid fuels for transportation or solid fuel for electricity. Table 6 provides conversions for these crops to displace coal and produce ethanol, the two most likely cellulosic biomass scenarios.⁵⁰

⁴⁹ Robinson et al, "Assessment of Potential Carbon Dioxide Reductions Due to Biomass-Coal Cofiring in the United States," *Environmental Science Technology*, 37 (22), 5081-5089 2003.
<http://pubs.acs.org/cgi-bin/abstract.cgi/esthag/2003/37/i22/abs/es034367q.html>.

⁵⁰ US Department of Energy, Biomass Feedstock Composition and Property Database, www.eere.energy.gov/biomass/progs/search1.cgi. US DOE, Oak Ridge National Labs, "Biofuels and Agriculture," 2001, <http://bioenergy.ornl.gov/main.aspx>. Conversations with USDA Forest Products Lab staff.

Table 6: Biomass Energy Content and Conversion to Ethanol and Coal

Biofuel	Energy Content (BTUs/dry pound)	Coal Replacement	Ethanol Potential (Gallons per Ton)
Wood	8,500-9,500	100%	70-116
Grasses	8,000	89%	75-100
Corn stover	7,300	81%	80-90
Manure, wet	2,110	23%	20-55

Providing dry material is the key to successful biopower project since wet fuel has less energy value. We assume manure could produce one-third the ethanol because it has one-third the energy content but more study is needed to characterize the cellulose make-up of manure. Calculations in this study are conservatively based on 60 gallons ethanol per ton and 66% PRB coal equivalency to be conservative.

Forage Definitions

Forage is material other than grain that is used for animal feed. Typical forage includes:

- Corn silage is the entire corn plant, including the stalks and leaves that are chopped at just above ground level. There is minimal crop residue left on the field after harvest.
- Hay consists of grasses alone, alfalfa (a legume plant that provides high quality feed) alone, or a combination of grasses and legumes. The quality of hay is greatly dependent on managing the hay properly. Some hay is considered wild hay, i.e., very little management is done other than harvesting the wild grasses and other plants on the site. Hay crops are either cut and baled or are “green chopped” where the forage is blown into a wagon and removed as “Haylage.”
- Grasses are:
 - 1) Domestic grasses commonly referred to as cool season grasses that are nonnative and have been planted (or now grow wild). Common grasses are smooth brome grass, timothy, bluegrass and orchardgrass.
 - 2) Native grasses are commonly referred to as prairie grasses or warm season grasses, although there are native cool season as well. Common native grasses include switchgrass, Big Bluestem, Little Bluestem, and Indiangrass.

There are major differences in the culture of native warm season grasses and domestic cool season grasses. The primary difference is that cool seasons come on strong during the moist times of the year; warm seasons have adapted to growing in the hot weather and can tolerate dry periods. The root systems of cool season grasses are relatively shallow whereas warm seasons can have massive root systems. These characteristics are important when planning biofuel systems.

The Conservation Reserve Program (CRP) has a cool season grass cover planting practice (CP-1) and also a warm season grass planting practice (CP-2).

Conclusion

This report shows a great potential for a variety of biomass sources to provide up to half of Wisconsin's liquid fuel or coal electricity. Biomass energy could create more jobs, reduce air and water pollution, help family farmers and reduce the largest sources of CO₂, a major greenhouse air pollutant. Realizing this potential requires more study and investments. More study is needed to further characterize these fuel sources, quality and costs. We also need to assess fuel distribution potential and integrator availability.

More funding is needed for pilot-scale demonstrations to test this research and bring these projects to market. If we seize this opportunity, we can make progress toward energy independence, help farm families, create good paying jobs, and improve air and water quality.

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Table 7: Estimated Total Excess Biomass Resources Available in 12 Midwestern States (Tons/Year)

State	Crop Residues	Switchgrass on CRP Lands	Forest Residues	Methane from Landfills	Methane from Manure Management	Primary Mill Residues	Secondary Mill Residues	Urban Wood	Methane from Domestic Wastewater	Total Biomass
Illinois	21,601,985	5,832,415	732,084	1,073,870	83,793	256,891	105,843	1,474,090	23,153	31,184,123
Indiana	9,896,362	1,773,980	951,488	579,934	84,895	632,856	78,280	788,313	11,025	14,797,133
Iowa	26,008,820	11,299,890	395,810	151,047	156,560	143,330	31,974	352,811	5,513	38,545,755
Kansas	8,394,708	6,917,310	147,740	153,252	24,256	31,974	20,948	366,042	4,410	16,061,742
Michigan	3,953,693	1,599,779	1,405,733	491,731	33,076	1,448,732	94,818	1,318,633	17,641	10,362,734
Minnesota	15,690,187	8,656,009	2,471,885	163,175	78,280	1,085,998	65,050	546,858	8,820	28,765,160
Missouri	6,622,933	9,341,786	2,028,666	300,992	132,304	1,142,227	76,075	675,854	9,923	20,329,658
Nebraska	12,051,819	3,686,880	79,383	52,922	112,459	62,845	14,333	208,379	3,308	16,272,326
North Dakota	7,278,942	11,550,165	29,768	5,513	4,410	441	7,718	73,870	1,103	18,952,591
Ohio	5,513,782	1,749,724	877,619	713,341	45,204	866,593	136,714	1,402,426	20,948	11,325,248
South Dakota	5,667,034	5,299,890	137,817	11,025	39,691	156,560	7,718	82,690	1,103	11,402,426
Wisconsin	4,872,106	3,446,527	2,217,200	300,992	20,948	1,787,211	76,075	604,190	9,923	13,336,273
MW Total	127,552,370	71,154,355	11,475,193	3,997,795	815,877	7,615,656	715,546	7,894,157	116,869	231,335,171
U.S. Total	173,312,018	92,141,125	62,416,759	13,649,394	2,413,451	85,033,076	2,883,131	34,070,562	512,679	466,432,194
% of National Total in MW	74%	77 %	18%	29%	34%	9%	25%	23 %	23%	50%

From: Milbrandt, A., "A Geographic Perspective on the Current Biomass Resource Availability in the United States," USDOE NREL, 2005, Page 49-50, www.nrel.gov/docs/fy06osti/39181.pdf compiled in the Perennial Bioenergy Feedstocks Report, North Central Bioeconomy Consortium, April 5, 2007, contact: Brendan Jordan, bjordan@gpisd.net, 612-278-7152.



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Almost 30 years of public service experience, including **Environmental Policy Advisor to President Clinton** and Energy Conservation Advocate in the Carter Administration during the 1970's energy crisis. Served as the **Senior Midwest Representative for the Sierra Club** in the nine-state Midwest Region focusing on air, water, agriculture, Smart Growth and wetlands issues. Worked on the 1985, 1990 and 2002 Farm Bills. Member of the Sustainable Agriculture Working Group and UCS Sound Science Initiative. **Brett has a master's degree in Natural Science** from the University of Oklahoma and a B.A. in Political Economy from Middlebury College.

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