Ushering in a Sustainable Bio-Economy

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The Great Plains Institute, formed in 1997, is a small non-profit operation focused primarily on policy related to energy and climate. A comprehensive strategy that uses a variety of energy technologies will be needed to deal with the challenges ahead—everything from biomass, wind, improved energy efficiency, hydrogen and other delivery systems, advanced coal technology with capture and storage, to hydroelectricity.

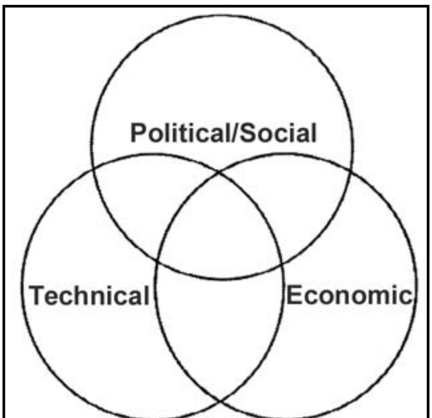

Figure 1. Test for feasibility of climate/energy solutions.

This conference is framing energy solutions in terms of technology, sustainability and profitability. I use a Venn diagram (Fig. 1) to think through things when evaluating a particular approach. The first issue is whether a scheme is technically feasible; engineers assist with that. The second issue is to evaluate the economics relative to other schemes proposed, for which methodologies are available. The toughest consideration relates to political and social dynamics; no textbook exists on whether an approach will be accepted by society.

Stakeholder Consensus as a Tool

We try to address social and political issues through stakeholder consensus. We have used this approach with a number of projects. Powering the Plains, a regional project in the Dakotas, Iowa, Manitoba, Minnesota and Wisconsin looking at the electricity sector, was created at the initiation of the conversation about climate change and energy security. The best approach was to bring the right people together for discussions in an environment in which they would not be quoted. Times have changed since then, and many of the leaders in that group are now very public about issues of energy security and climate change, and we hope that we played some small role in that; but obviously, the political dynamic has shifted. We have worked also with the Upper Midwest Hydrogen Initiative, a public/private effort to advance hydrogen and fuel-cell technologies. The Coal Gasification Work Group is focused on advanced technologies that allow capture of carbon dioxide. I've been involved also with the Biomass Working Group, a regional stakeholder group working on state policy related to biomass. And the Midwest Renewable Energy Tracking System (M-RETS) is a group of utilities, regulators and environmentalists that has worked to create a system that should be implemented in 2007 to allow regional trading in renewable energy credits.

We've also done some research on native grasses as feedstocks. The North Central Bio-Economy Consortium is a collaborative effort involving land-grant experiment stations, cooperative extension and state departments of agriculture. The idea was generated in July of 2006 at the Midwest Association of State Departments of Agriculture meeting. We launched the Consortium in April, 2007.

Bio-Belt

In the north-central states we are getting organized in this way because we are, in a real sense, the bio-belt. We have the bulk of the existing biorefineries as well as those under construction. As we move to advanced biofuels from cellulosic materials, it's been said that those materials will be spread more evenly across the country—which is certainly true—but it looks as though the north-central region has a great deal of that material as well, as indicated by studies by the National Renewable Energy and Oakridge National Laboratories.

One of the efforts that we have participated in—which I am pleased that I can finally talk about in public as it's been behind the scenes for a long time—is an energy summit for Fall 2007 as a key part of the 2007 agenda of the Midwest Governors Association, chaired this year by Governor Doyle of Wisconsin; the North Central Consortium has been invited to provide input.

Figure 2 contrasts CO_2 emissions in 1960 and 2005, by sector and fuel, for eight states in the Midwest. Clearly we should focus little attention on natural gas in the transportation sector—coal in the electricity sector and oil in the transportation sector are the main producers of CO_2. While there is technology that allows us to produce electricity from feedstocks other than coal with less CO_2 emission, there are fewer options for the transportation sector. Biofuels hold great promise for transportation, but not without possible adverse aspects:

- Competing land uses (food vs. fuel);
- Possible economic failure of ethanol plants;
- Loss of acreage in permanent cover;
- Loss of soil carbon;
- Loss of wildlife habitat;
- Diminished water quality.

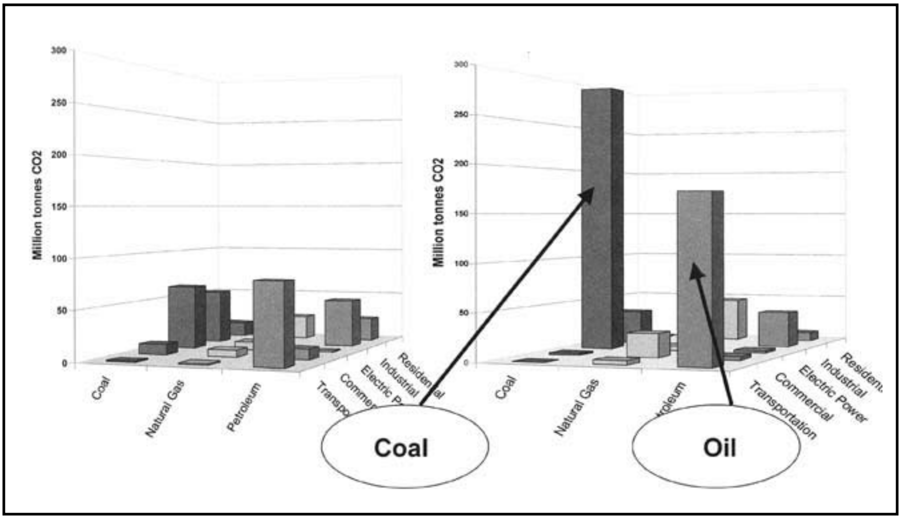

Figure 2. CO_2 emissions for eight Midwest states, from coal, natural gas and petroleum, in the transportation, commercial, electric-power, industrial and residential sectors.

Furthermore, although corn ethanol, soy biodiesel, canola biodiesel and other fuels from commodity crops will play increasingly important roles, other sources of bioenergy will be needed to realize the goals laid out in the president's 2006 state-of-the-union speech and by the 25×'25 committee[1]. Over the long term, we must displace petroleum—old biomass—with several types of new biomass, using approaches that preserve wildlife habitats, soil quality, water quality, maintain or increase farm income, encourage rural development and reduce greenhouse-gas emissions. The different types of biomass will variously impinge on soil quality, water quality, wildlife, *etc*. The so-called "billion-ton study" suggested that a total yearly production of 1.3 billion tons of biomass is feasible in the United States. I feel that this is a conservative estimate, in view of, for example, the seven-fold increase in corn yields since the 1930s; breeding, selection, hybrid and molecular technologies, *etc*., are likely to have similar effects on the yields of energy crops.

Biomass Development

The economics of ethanol production from biomass indicates a variety of opportunities. One estimate suggests that switchgrass with a farmgate price of $40/ton would produce ethanol equivalent to gasoline from oil at $15/barrel, and at $50/ton the oil equivalent would be only $18/barrel. The comparisons are less favorable against energy from coal and natural gas, but these calculations fail to take account of downstream costs of CO_2 release to the atmosphere. The economics of the cellulose-conversion technology is the major stumbling block.

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[1]See pages 43–46.

How many years away are we from commercial cost-competitive cellulosic ethanol? At least 5? Another technology at the demonstration stage and close to commercially viable is pyrolysis[2]—a thermochemical process that converts any kind of biomass material to bio oil, a mixture of chemicals similar to crude oil. Ensyn, a company in Wisconsin, converts about 10% of the bio oil it produces to liquid smoke, a flavoring for bacon, etc., and the rest is burned off as boiler fuel. At least twenty companies are exploiting gasification processes in the United States, with many applications. This is a way to demonstrate the utility of biomass feedstocks while awaiting economically viable cellulosic ethanol. Two companies in Minnesota—the Chippewa Valley Ethanol Company and the Central Minnesota Ethanol Cooperative—are gasifying biomass to replace natural gas. The managers of ethanol plants don't particularly like spending $15 million a year on natural gas; fortunately they can often buy biomass from the people supplying them with corn, thus this is an incremental step towards cellulosic ethanol: a proven technology can be used to demonstrate a feedstock. They don't have to manage multiple risks. Once the utility of a feedstock has been demonstrated, they may consider producing liquid fuels through an enzymatic or thermochemical process.

In the Cheritan Valley biomass project in southern Iowa, an 800-megawatt coal-fired powerplant uses switchgrass (at 2%) along with coal. It consumes up to 14 tons/h of switchgrass grown on CRP land. Much is being learned regarding the logistics of biomass supply, transportation and storage, directly applicable to other switchgrass-based technologies. Similarly, we have the opportunity to appraise the utility of a variety of biomass feedstocks—with specific state/locale relevance—while cellulose-conversion technology is being optimized. Accordingly the following feedstocks are under study in the indicated states:

- Corn stover: IA, IL, MN, IN, OH
- Switchgrass/grass polycultures: IA, ND, SD, KS, NE, MN, IN
- Wheat straw: ND, SD, NE, KS
- Sorghum: IA, KS, MO
- Wood residues: MI, MN, WI, MO
- Dedicated woody crops: MN, MI, WI, MO, OH, IN
- Miscanthus: IL

Win-Win Opportunities

Agronomic and forestry research on productivity will remain important, but we're at a point where research alone is not going to take us where we need to go. We do need to learn how to deploy. We need to partner with energy producers so that we are not just growing, collecting and storing. Feedstocks need to have markets that will probably need supports at first; but the best way to understand the logistics involved is to actually

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[2]See pages 127–135.

deliver them to processors. We cannot expect farmers and producers to take on all the risk, therefore we need to partner with them at least until we figure out how this is going to work. Incentives need to be in place.

While feedstock logistics will be a challenge it's also the area where we have the greatest opportunity for cost reduction. We need to partner with equipment producers, custom harvesters, manufacturers, and a variety of other commercial entities with relevant experience. And involvement of state departments of agriculture and land-grant research and extension experience will be necessary. Many "win-win" opportunities exist with a variety of feedstocks; much may be learned as we produce and deploy them in demonstration projects, for example:

- Corn-stover removal can increase no-till and conservation tillage;
- Cover crops can create biomass supply while improving soil carbon, water quality;
- Forest residue removal can decrease fire risk, improve lumber quality, and potentially improve habitat;
- Tree crops can be managed as mixtures.

For example in Minnesota and the northern region in general, removal of some, but not all, stover may open the soil to a small extent, favoring seed germination, allowing the soil to reach higher temperatures more quickly in the spring and could allow no-till and other conservation tillage practices to move further north. There's a variety of different cover-cropping approaches that add soil carbon and improve soil quality and could be paid for by biomass markets.

Forest-residue removal offers a number of opportunities. Removal of some smaller diameter trees can increase the eventual size and value of other trees. In some instances, management practices are already employed, so the price of the biomass doesn't have to cover the cost. Wildlife habitats may also be improved. None of these things are automatic, but there are opportunities.

In DOE-funded research that we helped conduct at South Dakota State University, the University of North Dakota Environmental Research Center and the University of Minnesota, we looked at simple mixtures of two to three species of native grasses—switchgrass, big blue stem and Indian grass. The switchgrass mixtures produced only slightly lower yields than did the monoculture. It's noteworthy that switchgrass is the only crop of the three to have been bred for yield; big blue and Indian have been bred as high-protein forages. Not surprisingly, the grasslands with greater plant-species diversity had higher bird-species richness and density. Diversity was similar in harvested and unharvested plots, but the species differed, suggesting that some combination in harvested and unharvested grasslands will offer the best opportunity for maximizing wildlife habitat.

Data from other switchgrass projects indicate that ash content peaks in July and August and steadily decreases through the winter. This is relevant to industrial processing because ash causes slagging with pyrolysis and related technologies. Harvesting in the fall or through the winter also will provide the opportunity to maximize bird habitat and avoid harvesting during the primary nesting season.

Growing perennial crops for biomass provides opportunities for increased carbon sequestration. There may be further opportunities for sequestration enhancement through breeding, conservation tillage and increased rotation length in forestry systems.

Improving Communication

In traveling around the region, I get the sense that one hand doesn't always talk to the other hand. Iowa needs to know what Nebraska is doing, for example; we are all learning as we go and there's no need to reinvent the wheel every time we want to get a corn-stover gasification project up and running. Everyone can benefit from better sharing of information, from regulators to project developers. It would be beneficial to all to have a resource directory of all of the research projects on various feedstocks and conversion technologies, both regionally and nationwide, and a comprehensive list of demonstration projects in each state. NABC might take the lead in these endeavors—much sharing of information and collaboration would likely follow.

The North Central Bioeconomy Consortium website is at www.ncbioconsortium.org. Information on our native-grass research is available at nativegrassenergy.org and the Great Plains Institute website is at www.gpisd.net.

BRENDAN JORDAN joined the Great Plains Institute, Minneapolis, MN, in 2004, where he manages the cellulose initiative. His work emphasizes the development of biomass as a resource for creating value-added energy and other products in order to displace fossil fuels, stimulate rural economic development, improve air, soil and water quality, and address global warming. Since August 2006, he has staffed the Biomass Working Group, a 55+-member stakeholder group in the upper Midwest developing state-policy recommendations for advanced biomass technologies.

With Sara Bergan, Mr. Jordan works on the Institute's US Department of Energy-funded native grass energy research—a collaborative project involving South Dakota State University, the University of North Dakota Energy and Environmental Research Center and the University of Minnesota.

Jordan, a graduate of Carleton College in Northfield, MN, has an MS in science, technology, and environmental policy from the University of Minnesota's Humphrey Institute of Public Affairs. His international experience includes a Judd Fellowship at the Center for Environmental Studies in Budapest, Hungary.