Biomass: Which Road to Take?

David Morris
Vice President
Institute for Local Self-Reliance

October 2001

Background

Little more than a century ago the raw material foundation of even emerging industrial economies was comprised largely of plant matter. In 1820 Americans used about two tons of vegetables for every one ton of minerals. As late as 1870 about 65 percent of our energy was generated from wood.

By 1920 the raw material foundation of the economy had changed. Americans were using two tons of minerals for every one ton of vegetable. In 2000 we used about 8 tons of minerals for every one ton of plant matter, and about 4 tons of hydrocarbons for every one ton of carbohydrates.

In the last 20 years, plant matter has begun to make a comeback as a competitor with minerals, a result of engineering and political developments.

On the engineering front, technological advances have lowered the cost of making bioproducts and biofuels. The cost of industrial enzymes, for example, has dropped by almost 90 percent. Products from these engineering advances usually first target high value, low volume medical markets. Thus lactic acid derived from milk sugars has been used for many years to make a degradable plastic, polylactic acid(PLA), used to make sutures for surgery inside the body. The cost was some $100 per pound. Today PLA is being made from corn sugars. The cost per pound has dropped to about one dollar, low enough to open up a potentially huge textile and injection molding market.[1]

On the political front, environmental regulations have raised the cost of extracting and processing minerals and disposing of products made from them. When lead was phased out of gasoline, for example, oil refiners had to use a more expensive octane enhancing additive. This made ethanol more competitive. Some countries now ban the use of mineral oils in chain saws and motor boats. Some counties have banned the use of non degradable plastic bags for storing yard waste, making starch and sugar based degradable plastics more competitive.

Recent policy initiatives and commercial developments promise a dramatic expansion in the use of plant matter for non food and feed purposes.

•On the global level, the embrace of the Kyoto Protocol by virtually all countries, except the United States should encourage strategies that favor carbohydrate-derived products and fuels over hydrocarbon-derived products and fuels.

• In 1999 Congress extended the ethanol tax incentive until 2007. That same year California became the first state to phase out MTBE, a gasoline additive that comprised some 12 percent of that state's gasoline and is the most widely used oxygenate in the country. As of September 2001, 12 states have begun to phase out MTBE(Arizona, California, Colorado, Connecticut, Illinois, Iowa, Michigan, Minnesota, Nebraska, New York, South Dakota and Washington) In June 2001 the EPA denied California's request for a waiver from the oxygenate requirement of the Clean Air Act. As a result of this combination of policy initiatives consumption of ethanol should triple to 4.5 billion gallons by 2004.

•In 2001 the EPA has issued new regulations dramatically reducing the amount of sulfur allowed in diesel fuel, opening up a large potential market for vegetable oils and ethanol.

•In June 2001, the EPA ruled that effluent from leaking hog manure lagoons would be regulated as a hazardous waste and ordered Seaboard

---

[1] The tendency of companies to invest in higher value, lower volume markets continues to hamper commercialization of technologies aimed at mass markets. Thus Chemical Week recently observed that federal "funding is important because companies such as Genencor are eying higher margin opportunities in fine chemicals and drug development opportunities that could forestall investment in bioprocesses." March 14, 2001.

farms, one of the nation's largest pork producers, to eliminate the pollution. That order should spur a dramatic increase in the use of anaerobic digesters to capture the methane and reduce the odor and volume of the manure even without federal incentives.

•This session Congress is expected to expand and extend the biomass tax credit, potentially making it as useful a tool in expanding the production of bioelectricity as its companion, the wind energy tax credit has been in expanding the production of wind generated electricity.

•In August 1999, President Clinton issued Executive Order 13134 establishing a goal of tripling US use of biobased products and bioenergy by 2010. In June 2000, Congress enacted the Biomass Research and Development Act of 2000, Title III of the Agricultural Risk and Protection Act. It established an interagency group co-chaired by the Secretaries of Energy and Agriculture to coordinate federal-wide activities.

•The 2000 Agriculture Appropriations Act allowed up to 250,000 acres of Conservation Reserve Program(CRP) land to be harvested for the production of energy in up to six 10 year pilot projects. The Farm Bill passed by the House of Representatives in early October indicates the Secretary of Agriculture "may permit" harvesting of biomass for energy on CRP acreage with a reduction in rental rate. Nothing in the bill mandates such a program but the Senate version may contain mandates.

•Rapid fire developments have occurred during the past 12 months that may indicate a historic transition from the R&D to the commercialization stage of many new biobased technologies. One Canadian company, for example, is about to open the first commercial sized cellulose-to-ethanol facility. An Australian company is building a major commercial biomass gasification plant. Two American companies are building major biomass liquefaction plants. Two giant chemicals companies individually have announced the opening of large biochemical manufacturing facilities by late 2001 and early 2003.

Currently plant matter provides about 1 percent of our transportation fuels, about 2 percent of our electricity[2] and about 3 percent of our chemicals. All told we now use 150-200 million tons of plant matter for non food and feed purposes(excluding textiles, paper or wood construction products).

---

[2] About 10 GW, of which roughly 7 is generated by the forest products industry, 2.5 GW by municipal solid waste incinerators and about 0.5 GW from landfill gas.

An enormous potential exists for expanding biomass supply. By far the greatest quantity would consist of fast growing, largely cellulosic crops grown on unused or underused land. One calculation done in 1991 by James Cook and Jan Bayea of the Audubon Society concluded, "Overall, around 200 million acres of crop land might be suitable and available for energy or 'power' crops, without irrigation and without competing with food crops."[3] At the existing yield average of 5 oven dry tons per acre, this would yield 1 billion tons of biomass. In the near term, those yields could easily double to 10 tons per acre and in the longer term could double or triple again.

In the short term biomass for non food and feed purposes will tend to come from wastes. Environmentally recoverable agricultural residues(i.e. residues that can be taken off the land without undermining soil health) total about 250 million tons, with about half to two thirds of this coming from corn stover(i.e. corn stalks and leaves).

Urban organic wastes could contribute an additional 50 million tons, assuming that half of the waste now going to landfills could be diverted to industrial uses. Animals generate about 80 million tons of manure a year, with more than half of that in concentrated facilities where the manure can be easily gathered and processed.

Thus the total is about near and medium term amount of biomass available for industrial processing is near 1.4 billion tons per year(excluding aquatic sources).

If we use 250 million tons as a near term achievable supply figure and if all that plant matter were directed to a single market we could produce about 20 percent of our transportation fuel, or about 90 percent of our chemicals, or about 5 percent of our electricity.

Discussion

From an environmental perspective, an increased use of biomass must be part of any sustainable strategy because unlike direct sunlight

---

[3] James Cook, Jan Bayea, and Kathleen Keeler, "Potential Impacts of Biomass Production in the United States on Biological Diversity", Annual Review of Energy and the Environment, 16:401-431. 1991. Estimates vary significantly but this figure is a good working number by a respected environmental organization that is viewed as very cautious regarding the use of land for energy purposes.

and wind power, biomass contains molecules. It is the only renewable resource that can be used for making physical products.

In addition, biomass has its own built-in storage system. As a result, it can provide energy on demand, unlike intermittent energy resources like wind and sunlight.

Still, designing an effective and durable biomass policy is a challenge. The challenge for policy makers and activists results from the fact that the properties of biomass differ in at least three fundamental ways from other renewable energy resources like wind and direct sunlight. Thus while biomass policy makers can learn from solar and wind policy experiences, they must also develop a unique strategy.

•Sunlight and wind can be harnessed only to generate some form of energy(e.g. heat, mechanical power, electricity). But plants can be harnessed for many end uses(e.g. food, feed, textiles, paper, construction products, liquid fuels, solid fuels, chemicals, fertilizer, and soon, subsoil carbon sequestration).

The Energy Policy Act of 1992 ignored this characteristic, with predictable results. EPAct restricted its biomass tax incentive to biomass "planted exclusively for purposes of being used to produce electricity". Ten years later, hundreds of wind farms have taken advantage of the Act's identical incentive for wind energy, but not one biomass facility has done so. Plants are rarely if ever grown for single product markets on long term contracts.

•The harnessing of sunlight and wind has modest, perhaps even trivial environmental impacts. The cultivation and harnessing of plant matter, on the other hand, can have profound environmental impacts.

In a series of workshops held in the early and mid 1990s, representatives of the forest products industry, environmental organizations and utilities met to develop criteria for the use of bioenergy. Their conclusion? "Large scale bioenergy development could bring significant ecological benefits--or cause equally significant damage--depending on the paths taken."[4] The group noted that it "was unable to reach substantive agreement on any of the issues associated with forest harvesting for energy." In 1994 a study funded by DOE and NREL and EPRI

[4] Jim Cook and Jan Beyea, Bioenergy in the United States. Progress and possibilities. Biomass and Bioenergy 18(2000)-441-455.

concluded, "although there are major uncertainties due to knowledge limitations, it appears that the net ecological implications of biomass crop production are neutral to positive while the net ecological implications of forest harvesting are neutral to negative."

•The quantities of sunlight and wind available for harvesting are unaffected by public policy. The sun will shine and the wind will blow no matter what government does. This allows advocates to focus on the cost and efficiency of conversion technologies. But plant matter is available in large quantities only if farmers cultivate it and deliver it to a market. Thus the farmer must become an active partner and a key focus of public policy.

The unique properties of biomass require that policy makers strive to achieve three objectives, often simultaneously.

1) maximize the substitution of living fuels for fossil fuels ;
2) minimize the environmental impact of raising and processing the vast increases in plant matter needed to achieve the first objective; and
3) maximize the beneficial economic impact on cultivators and rural communities.

A cautionary tale

In 1997 an outbreak of pfisteria in the Chesapeake Bay area was traced to pollution caused by the flow of phosphates into the water from high concentrations of poultry manure. The state of Maryland designed a coherent program to tackle the problem, ranging from encouraging the use of an enzyme, phytase, to reduce the amount of phosphorous in the manure, to paying farmers to transport the manure from environmentally sensitive areas to other areas for land application, to the creation of a competitive grant program to foster new technologies to make the best use of the manure.

Congress, however, responded in a different fashion. A bill successfully championed by the Senator from Delaware, then Chair of the Senate Finance Committee expanded the biomass tax credit to include poultry manure.

In some respects that federal policy echoed one established back in 1979 and 1980, when the nation discovered its garbage landfills were leaking while the price of oil and electricity soared. Federal incentives for garbage incinerators were viewed as reducing pollution and strengthening national security.

In essence, Congress offered an incentive equivalent to about $20 per ton for manure handlers but only if the end product was electricity. The problem was that poultry manure is one of the most attractive organic fertilizers. It is a dry manure, unlike hog or dairy manure and therefore easy to transport and store. It is high in nitrogen. The rapid growth of the organic foods market has increased the demand for organic fertilizers since farmers cannot gain organic certification if they use synthetic fertilizers. As a result, whereas in 1990 poultry growers often paid to have someone take their manure away, by 2000 they were being paid $4-6 per ton for their manure. A market had been created that channeled the manure to a high value, beneficial use.

The Congressional incentive and similar incentives enacted by states like Minnesota, will displace potentially millions of tons of high grade fertilizer. That would not only undermine soil health but would require the manufacture of more nitrogen-rich fertilizers derived from natural gas, a very energy intensive process.

An instructive tale

In the early 1980s Minnesota enacted a state tax incentive for ethanol patterned on the federal tax incentive: an excise tax exemption for each gallon of ethanol sold in Minnesota. Demand increased, but the ethanol sold in Minnesota came entirely from outside Minnesota from a giant firm. Minnesota farmers and the Minnesota economy did not benefit at all. In the mid 1980s Minnesota converted part of its pump credit to a producer payment. Only in-state production was eligible. The incentive applied only to the first 15 million gallons produced, for a l0 year period. Fifteen years later, as a result, Minnesota produces virtually all of its ethanol domestically. Farmers supply about ten percent of its automotive transportation fuel. The ceiling on payments encouraged many small and medium sized producers, and as a result, many farmer-owned enterprises. In 2001 there are l5 ethanol producers in the state and 11 of them are farmer-owned. About 15 percent of the state's grain farmers are shareholders in one or more ethanol plants. In 2001 many of them will receive dividends from the plant almost as high as the price they receive for their corn. The multiplicity of biorefineries has resulted in healthy competition and technological dynamism and a rooted business constituency that is politically powerful.

Recommendations for a Sustainable Biomass Policy

1) Make language consistent

Policy development has been burdened by the lack of a common definition of "biomass". The American Heritage Dictionary of the English Language(Third Edition) offers as the first and preferred definition of biomass, "The total mass of living matter within a given unit of environmental area". In some respects, that might be considered the commonsensical, real world definition. But the Dictionary offers a second and almost equally acceptable definition: "Plant material, vegetation, or agricultural waste used as a fuel or energy source." That definition emerges from the policy making world. Indeed, as a result of the dominance of the U.S. Department of Energy in this arena, the term "biomass" has come to be defined even more narrowly as a cellulosic crop or material used to generate electricity.

This linguistic confusion is compounded by the fact that both fossil fuels and plants, because of an accident of history, are called and considered "organic" materials. Thus when Green-e defines biomass for purposes of its certification process as "any organic material such as...." it unwittingly includes fossil fuels. When the High Plains SEED coalition recommends a federal Renewable Portfolio Standard(RPS) that includes renewable resources like "biomass" but "excluding non-organic solid waste incineration" it unintentionally supports the incineration of urban organic wastes like plastics and paper and wood.

An indication of how confused and confusing the language has become is found in a recent e mail from a very able activist in the energy and environmental area who recommended with regard to federal legislation, "Require an increasing percent of liquid fuel to be derived from biomass, steadily increasing the production of ethanol and bio-diesel from plant materials."

This definitional Tower of Babel occurs at the highest policy levels. In June 2001 three Senators separately introduced three bills to promote biofuels.

S. 670, The Renewable Fuels Act of 2001 defined a renewable fuel this way: "In General-The term'renewable fuel' means motor vehicle fuel that--1) is produced from grain, starch, oilseeds, or other biomass; or is natural gas produced from a biogas source, including a landfill, sewage waste treatment plant, feedlot, or other place where decaying organic material is found.... ii) Inclusion--The term 'renewable fuel' includes cellulosic biomass ethanol".

S. 1006, The Renewable Fuels for Energy Security Act of 2001 contained a much narrower definition of renewable fuel: "1) biodiesel; ii) ethanol or any other liquid produced from biomass; or iii) biogas... 4) In general-The term 'biomass' means lignocellulosic or hemicellulosic matter that is available on a renewable basis."

S. 892, The Clean and Renewables Fuels Act of 2001 considered a fuel to be renewable if it "i) is produced from ---I)agricultural commodities, agricultural products, or residues of agricultural commodities or agricultural products; II) plant materials, including grasses, fibers, wood and wood residues; III) dedicated energy crops and trees; IV) animal wastes, animal byproducts and other materials of animal origin. V) municipal wastes and refuse derived from plant or animal sources and VI) other biomass."

One lesson we might learn from these examples is that we get into trouble when we try to do too much with our definitions. It may be preferable to begin with a uniform, commonsensical and inclusive definition of biomass. This may be along the lines of the beginning of the Department of Energy's definition on its web site, "any organic matter which is available on a renewable basis" or an industry-spawned Bioenergy Vision statement, "material derived from biological origins within biological time". Or simply, "material from plants or from animal or human wastes."

The next question regards qualifications. What types of biomass would we exclude? There appears a consensus at least on some of these types: postconsumer waste paper which can be recycled, mixed municipal solid waste, painted, treated or pressurized wood or wood contaminated with plastic or metals, and tires.

From there the consensus breaks down. A key sticking point is the use of wood, especially forest residues. Of the 17 states that have renewable portfolio standards, nine have some form of restriction on kinds of biomass that are eligible. Connecticut and New Jersey require that the biomass must be "cultivated and harvested in a sustainable manner". Nevada says it must be "naturally regenerated". Rhode Island requires that it be "sustainably managed". Oregon requires that it be "low emission, non toxic biomass".

These terms are not defined, and we can learn from the controversy surrounding the implementation of "sustainably managed" forestry for the production of lumber and paper.

The Sierra Club, in a policy guidance statement issued in 2000, notes, "We are cautious in supporting projects based on 'clean' construction waste, forest byproduct waste or sustainable waste such as municipal tree trimmings, because of the strong incentives for plant managers to use unsustainable or contaminated fuel if the intended supply runs short."

2) Strive to design policies that encourage and enable the highest value end products and the greatest flexibility for producers and manufacturers

Sometimes this can be achieved through adopting more sophisticated legislative language. For example, at the suggestion of Bill Holmberg, Senator Jeffords included in his bio energy bill an incentive for the conversion of animal waste to electricity "provided that such waste is converted to a fuel rather than directly combusted and the residue is converted to biological fertilizers, oils or activated carbon." The result was to encourage value-added and more sophisticated technologies. Massachusetts has taken a similar tack by encouraging "low emission, advanced biomass power conversion technologies, such as gasification using such biomass fuels as wood, agriculture, or food wastes, energy crops, biogas, or organic refuse-derived fuel".

Another strategy might be to provide incentives on a per ton basis rather than for a specific end-product. Thus Maryland offers a $10 per ton incentive for manure handling. The California Agricultural Biomass Utilization Account awards $20 per more per ton of rice straw for each ton diverted from burning.

One reason to avoid anointing a particular technology or a particular end use is that it distorts technological developments and could restrict flexibility. For example, a focus only on direct combustion could ignore new more flexible technological processes that allow for multiple end-products. Burning cellulosic materials destroys the sugars, important building blocks for high value chemicals. If on the other hand, the cellulosic and hemicellulosic sugars are extracted, the energy content of the remaining lignin jumps from 12 to 24 million Btus per ton. Similarly, pre-commercialization efforts are currently focusing on extracting high value fibers from cattle manure, or chemicals from animal manures.

One company, Ensyn, has developed a rapid pyrolysis process to convert wood to a biooil. In the early 1990s it began selling this to Red Arrow, a food additive manufacturing company that uses it as part of its industrial process. In the late 1990s, with federal financing, Ensyn experimented with co-firing the biooil in a coal power plant. The project was successful, but as Red Arrow's sales expanded, the biooil was redirected to this higher priced use. As CEO Robert Graham indicated, "It is possible that in the future Ensyn will establish RTP(Rapid Thermal Processing) facilities which are 100% bio-fuel related. Nevertheless, under present market conditions, we believe that the most attractive economies are in adopting a refining approach to this industry, based on the extraction of higher value natural chemical components first, and the use of remnant bio oil and other byproducts in lower value applications such as fuels."

It is useful to think of biomass as a material that can generate many different kinds of fuel. For example, a hydrogen economy could well be a carbohydrate economy. As Eric Larson and Ryan Katofsky have concluded, biomass "is expected to be the most cost effective renewable option at large plant sizes."[5] The beauty of direct hydrogen production from biomass is that a renewable energy source is used without the need for electrolysis, leading to a higher system efficiency and a more favorable overall result.[6]

3) Accept and grapple with the fact that a significant near term expansion in the use of biomass to generate electricity depends on a partnership with the forest products industry and coal-fired power plant operators

Today the majority of electricity and energy generated from biomass is generated by the forest products industry. Currently some 60 percent of the heat and electricity needed by this industry is produced internally. Yet the efficiency of the incinerators that burn the black liquor, a pulping byproduct, is very low, about 12 percent. By substituting higher efficiency power generation processes they could almost double their electrical output, becoming not only self sufficient but exporters of

---

[5] Eric D. Larson and Ryan E. Katofsky, Production of Hydrogen and Methanol via Biomass Gasification. Advances in Thermochemical Biomass Conversion. Elsevier. London 1992.

[6] Water contains 12% hydrogen and biomass contains 6%. but conversion efficiencies of biomass to hydrogen are higher, 70% versus 55%.

several gigawatts of power.

The least expensive form of biomass electrical generation occurs by adding 3-10 percent biomass to a coal fired power plant. For a typical large multi-unit coal fired power plant complex, this would be the equivalent of building a 50-100 MW, l00 percent biomass fueled power plant. The cost of co-fired biomass is about 2-3 cents per kWh while the cost of a electricity from a l00 percent biomass fueled generator is about 6-8 cents per kWh.

Currently two barriers have inhibited cofiring. One is the increased managerial cost involved, a cost not sufficiently offset by the reduced SOx pollution that occurs by adding the biomass. The second is the federal government's requirement that coal fired power plants that use biomass meet new source performance standards. This increases their cost. On the other hand, environmentalists are concerned that if this were not required, that biomass would be a means to actually increase the burning of coal in older power plants.

4) Analyze more comprehensively and adequately the environmental impacts of various forms of biomass and biomass processing

Powering the Midwest, an excellent document prepared by the Union for Concerned Scientists and the Environmental Law and Policy Center, recommends a massive increase in the use of biomass to generate electricity. Forty nine percent of the biomass would consist of switchgrass, 42 percent crop residues and 9 percent logging residues. None would consist of fast growing trees like poplars. That may be a valid conclusion but the report contains no analysis to support it.

One advocate of fast growing trees makes the following case in support of his position.

With switchgrass, 4-10 percent ends up as ash while for poplars it is only .67 percent. These are minerals that come out of the soil and must be replaced. To get comparable yields, switchgrass will need fertilizer levels approaching those of corn while fast growing trees need 1/3-1/2 the fertilizer application as corn. Moreover, fast growing trees require fertilizer applications only once every five years while switchgrass could require it every year. Switchgrass harvests the leaves, which contains nitrogen and minerals and protein. Tree's leaves fall to the ground. Switchgrass is harvested twice a year, which eliminates habitat. Trees are harvested once every 5 years. Switchgrass suffers a 10 percent storage loss. Trees have zero storage losses.

I include this obviously one-sided rendition simply because nowhere have I found an analysis that compares switchgrass and fast growing trees, a remarkable oversight given the overwhelming tendency for the environmental community to enthusiastically embrace the former while being largely suspicious of the latter.

To provide another provocative example, Gregory Morris of the Green Power Institute concluded, in a study done for the National Renewable Energy Laboratory(NREL) that composting releases such substantially greater amounts of methane than does the direct combustion of wood, that the greenhouse gas impact of composting is several times greater than the greenhouse gas impact of incineration.[7] If valid, this conclusion could, at least from a climate change perspective, argue for providing incentives for combustion rather than composting. Yet in California, for example, state law(AB 939) requires cities and counties to divert 50 percent of their waste from landfills by 2000. The law allows counties to gain no more than 10 percent credit for diversion when it includes "transformational" processes. These are defined as incineration, pyrolysis, distillation, gasification, or biological conversion. They do not include composting.

5) Make farmers active and enthusiastic partners

Farmers must buy into a biological economy. To do so we need to work with them where they are. Grain farmers currently grow by far the largest quantity of plant matter in the country and have very sophisticated cultivation, harvesting and processing capacities. Thus it might be useful to work with the corn farmers to encourage the use of the cellulosic component of corn as a possible add on in the front end of an ethanol plant, or with the soybean farmers to work on higher value markets for their vegetable oils, or wheat farmers to work with developing markets for their straw.

Current estimate by Jim Hettenhaus are that corn farmers, for example, could receive a net of $15-20 per acre simply by selling a portion of their cellulosic residues to a processing plant. That is about as much net income as a farmer often makes in an average year.

---

[7] Gregory Morris, The Value of the Benefits of U.S. Biomass Power. NREL. November 1999.

We should also accept that farmer and rural community welfare will not necessarily improve simply because of expanded markets. Expanded markets are a necessary, but not sufficient condition for improving the welfare of farmers. As farmers are aware more than anyone, expanded markets in the past have not resulted in increased net income to the farmer. This is because, as John Kennedy once observed, "The farmer is the only man in our economy who buys everything retail, sells everything he sells wholesale and pays the freight both ways."

In 1910 of every dollar generated by agriculture, the farmer received 41 cents. By 1990 the farmers share had dwindled by more than 75 percent, to just 9 cents. And today it is closer to 7 cents. Yet this reduction in the farmer's income has not resulted in a reduction in the retail prices of the products made from the farmers raw materials. The price of a pound of corn flakes has gone up some 50 percent in the last 15 years while the price of a pound of corn has gone down.

Higher farm yields and expanded markets for farm products do not inevitably translate into higher net income for the farmer. To achieve that farmers need to embrace the other pillar of the carbohydrate economy: farmers receiving a portion of the profits earned beyond the farm gate.

Consider the differential impact of an expanded market for ethanol on farmers who sell their corn to ethanol producers compared to farmers who own the ethanol producer. The impact on the first is an increase in price by maybe 10 cents a bushel. The impact on the second can translate into a dividend of 25-75 cents a bushel. Indeed in 2000 corn farmers who were shareholders in an ethanol plant received almost as much in dividends as they did for their corn, on a per bushel basis.

Today there are over 100 farmer-owned factories. All are less than 25 years old. Most are less than l0 years old. Public policy at the federal and state level can and should support such forms of ownership as a way of maximizing the benefit of expanding biomass markets to rural areas and the cultivators.

6) Consider the issue of scale when designing policies

In some respects, this recommendation is a corollary and companion piece to number 5. Yet it is also distinct. As many studies have shown, healthy rural economies and communities demand a diversity of small and medium sized producers and cultivators. In the last 30 years there has been an increasing concentration in the agricultural sector, particularly in the livestock sector. From an energy perspective, this may be viewed as an opportunity. The concentration of livestock means a concentration of manure and that concentration lends itself to the capturing of methane and the generation of heat and power. Yet concentration also undermines diversity and the vitality and viability of rural economies.

At the state and federal level there are now direct grants given to concentrated livestock operators for them to install energy generation equipment, as a pollution reduction strategy. At the federal level several bills would extend the biomass tax credit to the generation of electricity from these operations. The problem posed by these strategies is in some regards similar to that discussed above with regard to the poultry manure-to-electricity incentives. Yet it is also different. Dry manure already has a healthy and growing market so incentives in that area undermine the organic fertilizer market. Wet manure, because of transport costs, does not yet have a large land application market.

Yet because large manure lagoons pose an environmental danger, a regulatory process would appear to be a more appropriate strategy to embrace than an incentive process. As noted above, the EPA has declared leaking hog manure lagoons in Oklahoma as similar to leaking landfills and has required the livestock owners to clean up the problem. Currently the payback period on capturing the methane and generating electricity from it(and having as a byproduct a good fertilizer) is 4-10 years. Larger operations tend to have shorter payback periods.

In the livestock sector a strong debate is raging about concentrated versus dispersed livestock raising in the hog, dairy and cattle industries. A dispersed "hoop house" operation for hogs, or pasture rotation with dairy cattle, allows the manure to be deposited on the land. By rewarding concentrated livestock operations when they concentrate the manure and thus make it a pollution problem, one favors them.

Scale issues could be used to examine other biomass policies. For example, corn dry mills are smaller than corn wet mills. Ethanol production from dry mills tends to be in the 15-30 million gallon per year range, while ethanol from wet mills is in the 60-150 million gallon range. Should activists favor federal R&D policies that encourage technologies geared to smaller rather than larger processing plants?

Finally, incentives can be targeted to smaller scale producers or cultivators. This has occurred, as noted above, in Minnesota with regard to ethanol production. Minnesota also, interestingly, provides payments to smaller wind operators(2 MW or under).

7) Adopt a nuanced approach to genetic engineering

The environmental community has formed a consensus against the use of genetically engineered crops. Yet the largest single focus of federal biomass R&D money appears to be directed at genetically engineering forms of biomass. Yet unlike in the food arena, in the non food and fuels arena, the stance toward genetic engineering can be more nuanced.

We might adopt an"inside-outside" approach to genetic engineering that could move us away from the current "all or nothing" debate.

"Inside" genetic engineering alters microorganisms to dramatically improve productivity, lower costs, and reduce pollution from industrial factories. In the last five years, worldwide use of this technique has soared. Sales of industrial enzymes are over $1.6 billion. Sales of biocatalysts have surpassed $150 million and are growing rapidly.

"Inside" genetic engineering offers dramatic benefits: a reduction in cost by 40-60 percent, an increase in yields of 40-100 percent, and the virtual disappearance of environmental pollution. The downside risk, while not zero, is very low.

The benefit of "outside" genetic engineering, on the other hand, seems modest, even in the short term. The National Center for Food and Agricultural Policy, funded in part by agribusiness, released a study on the subject last April. It reported that genetically engineered Roundup Ready soybeans have the same yield and require the same volume of chemicals to kill weeds as traditional varieties. The Center found that other benefits to farmers generating savings of about $3.75 an acre.

On the other hand, a report in early 2001 by the USDA found that Illinois farmers who can guarantee they are growing traditional varieties of soybeans were commanding a premium of 20-25 cents per bushel. That amounts to $8-10 per acre.

When it comes to genetic engineering in the factory, there is no alternative biological strategy. When it comes to genetic engineering in the field, however, there is. This was dramatically confirmed last summer with the publication in Nature of the results of China's tests with rice. As British environmentalist George Monibot observers, the Chinese scientists "tested the key principle of modern rice growing--planting a single, high tech variety across hundreds of hectares, against a much older technique: planting several breeds in one field".

The results were remarkable. Rice blast, a devastating fungus which normally requires repeated applications of poison to control, decreased by 94 percent. Moreover, yields increased by 18 percent. In 1997 only a few acres were planted. In 2000 this grew to 150,000. "Eventually, we'll see the whole Yunnan Province involved" says Dr. Tom Mew, director of the project at the International Rice Research Institute, "That's close to one million hectares(2.5 million acres) of rice farming."

Organic farmers also worry that they will lose their organic certification if genetically engineered crops from a neighbor's field pollinate their own. And of course, in the long term, we know nature will adapt and react to the introduction of these new species. We just don't know how.

An inside/outside approach could guide public policy. For example, currently Cargill/Dow has used genetic engineering in the factory to make the cost of a 100 percent plant-derived plastic competitive with its petrochemical counterparts. At the same time, scientists have been genetically engineering corn so that the plant produces its own plastic. Both rely on genetic engineering. Yet the first, an example of inside genetic engineering, has benefits that far exceed its costs. The second, an example of outside genetic engineering, has costs that far exceed its benefits. Currently the federal government supports both. It makes no distinction between the two strategies. It should.

Conclusion

Plant matter must be an important element in a sustainable economy because it is the only renewable resource from which we can fashion physical products. In the next few months and years we will be making decisions at the local, state, national and international level that will channel tens, perhaps hundreds of billions of dollars of money into certain areas and markets. We are changing the rules regarding the way we generate and distribute energy, the way we farm, and the way we relate to the environment. As a result we are channeling investment capital, scientific genius and entrepreneurial energy in certain directions.

A carbohydrate economy is a strategy that can marry environmental and national security and economic development objectives. Yet the very nature of biomass makes it a controversial and complex arena for decision making.