ACCELERATING THE SHIFT TO A CARBOHYDRATE ECONOMY: THE FEDERAL ROLE

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of the Biomass Research and Development
Technical Advisory Committee

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Ann M. Veneman
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The Institute for Local Self-Reliance (ILSR) is a nonprofit research and educational organization that provides technical assistance and information on environmentally sound economic development strategies. Since 1974, ILSR has worked with citizen groups, governments and private businesses in developing policies that extract the maximum value from local resources.

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Accelerating the Shift to a Carbohydrate Economy: The Federal Role

In June 2000 the Agricultural Risk Protection Act of 2000 (PL 106-224) became law. Title III of that law, referred to as the Biomass R&D Act of 2000, established the Biomass Research and Development Board. A Technical Advisory Committee was established to advise that Board.

This Committee was charged by Congress to submit an annual report to the Secretaries of Energy and Agriculture. That report was submitted in January 2002. A minority report was included. This paper echoes the language and perspective and summarizes the recommendations of the minority report.[1]

Local communities are the missing factor in the federal government's formula to replace hydrocarbons with carbohydrates in the United States' industrial economy.

The technology to accelerate a shift to a carbohydrate economy exists. So does the political will of policymakers. But little consideration has been given to the necessity of actively and enthusiastically involving farmers–the primary potential producers of raw biomass. And the economic and societal value of encouraging dispersed and diversified ownership of modestly scaled facilities largely has been ignored.

Any sensible, viable and effective federal policy must consider those two factors. First, because substantial and sustainable movement toward a carbohydrate economy will fail unless adequate supplies of biomass exist. Second, because rural communities will see few, if any, economic benefits if crops grown by nearby farmers are shipped and processed out of the area.

Background

Only a little over a century ago, our emerging industrial economy was a carbohydrate economy. We relied on plants, not only for food and clothing, but for fuels and chemicals.

In 1820, Americans used about two tons of vegetables for every one ton of minerals. Just before the Civil War, grain-derived ethanol and wood-derived methanol were among the nation's largest selling chemicals. As late as 1870, about 65 percent of our energy was generated from wood. The first plastic was made from cotton; in the 1890s, a later version launched the consumer photography industry.

By 1920, the raw material foundation of the economy was shifting direction. Americans used about two tons of minerals for every one ton of vegetables. After World War II this trend accelerated. By 1970, only traces of a carbohydrate economy remained. Vehicles used no biofuels. Electricity generated from biomass accounted for less than 1 percent of the nation's power. Almost two-thirds of our fibers were derived from petroleum. Vegetable oil-based inks had all but disappeared.

Then, slowly, the pendulum began to swing back, driven by technological and political advances.

On the technological front, the biological sciences and engineering made dramatic strides. This lowered the cost of producing bioproducts and biofuels. The cost of several industrial enzymes, for example, dropped by almost 90 percent from l980 to 1995.

On the political front, governments began to "internalize" the environmental costs resulting from extracting, manufacturing, and disposing of products made from fossil fuels. Sometimes this was done by offering incentives to cleaner products, sometimes by regulating dirtier products.

Regulations raised the price of products derived from nonrenewable resources. Banning nondegradable plastic bags, for example, made starch- and sugar-based plastics more competitive with petrochemical-derived plastics. Reductions in allowable sulfur emissions from power plants and trucks make biofuels more attractive.

This confluence of technological advances, more restrictive environmental regulations, and increased public incentives has encouraged the re-emergence of a

[1]To read the Committee's entire majority and minority reports see http://www.bioproducts-bioenergy.gov/

biological foundation for industrial economies. The consumption of biofuels in vehicles, for example, rose from zero gallons in 1977 to almost 1.5 billion gallons in 1999. Electricity generated from plant matter increased threefold between 1981 and 1997. The market share of soy inks in the U.S. more than quadrupled from 1989 to 2000, from less than 5 percent to over 22 percent.[2]

Plant matter now provides about l percent of our transportation needs, about 2 percent of our electricity needs, and about 3 percent of our chemical needs. Sufficient management, engineering, and marketing expertise and experience now is in place to allow for rapid expansion in all these sectors.

The potential is huge. In the continental U.S. alone, we might grow and harvest more than 1 billion tons of additional plant matter on a sustainable basis. Another 300 million tons of agricultural and urban wastes are available. The total amount of plant matter available for nonfood and feed purposes might be enough to completely replace petrochemicals with biochemicals, put a serious dent in our consumption of fossil fuels for transportation or modestly contribute to the nation's supply of electricity. In the process, thousands of new high-paying jobs would be created in rural areas.

Policymakers increasingly acknowledge the multiple benefits that would result from expanding our industrial use of plants: enhanced national security, reduced environmental pollution, increased farmer income, and improved rural well-being. In August 1999, Presidential Executive Order 13134 launched a national Bioenergy Initiative, "a national partnership...to produce power, fuels and chemicals from crops, trees and wastes." The Executive Order created a National Biobased Products and Bioenergy Coordination Office and established a goal of tripling the U.S. use of biobased products and bioenergy by 2010.

[2]For a more in-depth historical and market sector analysis see David Morris and Irshad Ahmed, *The Carbohydrate Economy: Making Chemicals and Industrial Materials from Plant Matter* (Washington, D.C.: Institute for Local Self-Reliance, 1992). Also see Ahmed and Morris, *Replacing Petrochemicals with Biochemicals* (Washington, D.C.: Institute for Local Self-Reliance, 1994).

Policy is the primary force for change

Governments can use three broad tools to effect change: spending, incentives, and regulation. Total annual federal R&D spending on nonfood and feed applications for biomass is about $250 million. The departments of Energy and Agriculture account for about 90 percent of the total. That level of spending, if properly coordinated and targeted, could play an important role in expanding a carbohydrate economy. But the driving force behind change, especially in the short term, will be public policy actions.

In the last 20 years, virtually all of the expanded use of plants for industrial purposes has been a result of policy changes. The federal goal of tripling the consumption of biofuels, for example, may be achieved by 2005: not as a result of research and development expenditures, but a combination of federal and state incentives, federal regulations, and the decision by 12 states to phase out the use of MTBE. Similarly, virtually all increases in the generation of electricity from biomass are a result of regulations (e.g., federal requirements for the capture methane from landfills).

Sometimes public policy complements and reinforces R&D spending. Sometimes it inhibits or even undermines such initiatives. Policy options should be integrated more fully into overall strategic planning.

Consider, for example, the case of co-firing. This is the addition of a 3-10 percent blend of biomass to a coal-fired power plant. This has the potential to vastly expand biomass for power generation. Co-firing is the least costly way to generate electricity with biomass. Significant R&D spending has been dedicated to commercializing co-firing, but efforts have not yet succeeded.

Various reasons have been offered. One is that power plant owners have been unable to guarantee access to significant quantities of low-cost biomass using long-term contracts. Another is that power plants that co-fire must, according to EPA regulations, upgrade the coal-fired facility to meet more rigorous new performance air emission standards. Still another theory is that the use of biomass changes the composition of the coal ash residue and may undermine the progress the electricity industry has made in getting the construction industry to certify the use of products made from coal ash. Still another theory is that insufficient R&D has been done to understand the long-term effects of co-firing biomass, especially agricultural residues, on power plant equipment.

Overcoming each of these barriers requires a different type of strategy. Expanding federal incentives might be the preferred strategy in one case. Changing regulations would be preferred in another. New institutional vehicles might be required in still another.

Decisions regarding R&D expenditures should be consistent with and complemented by policy initiatives.

A strategy to expand the use of biomass will differ from a strategy to expand the use of renewable resources

Expanding the use of plants for nonfood and feed purposes should be an important component of an overall strategy to expand the use of renewable resources. But plants boast at least three distinctly different characteristics than renewable resources such as wind or sunlight or water.

- The sun shines, the wind blows, and the rain falls regardless of human intervention, but plants will be cultivated and harvested in significant quantities only if cultivators are willing.
- Harnessing sunshine and winds results in few negative environmental impacts, while the cultivation and harvesting of plants can have a major environmental impact.
- Sunshine and winds can be harnessed only to generate some form of energy (e.g. heat, mechanical power, electricity) while plants can be harnessed for many end uses (e.g. food, feed, textiles, paper, construction products, heat, power, chemicals, fertilizer, and soon, subsoil carbon sequestration).

These distinct characteristics of plants argue for different public strategies. Initiatives intended to extract energy from sunlight and wind, for example, can focus on improving conversion efficiency and developing end markets for the electricity. But initiatives intended to expand the use of biomass for nonfood and feed purposes require strategies that attract farmers' active and enthusiastic participation. Expanding the use of biomass requires an environmental screen. And the multiple uses of plants should lead governments to exercise great caution before tying incentives to a single end use.

To illustrate the last point, in the early 1980s, the federal government offered handsome incentives as well as R&D grants for the production of electricity by incinerating urban wastes. Few incentives were available for expanding recycling. Communities were rewarded for building large incinerators that often foreclosed potentially more economical and valuable disposal options.

Today federal agencies may be imitating this earlier policy by encouraging "bioreactors": redesigned landfills that inject water to capture a larger quantity of the methane generated. Some worry that these incentives, like those for garbage incinerators, could skew technological development and foreclose more societally optimal options.

The desire to anoint a single end use, usually electricity generation, has plagued federal biomass policy. The Energy Policy Act of 1992, for example, offered a biomass incentive only to crops "planted exclusively for purposes of being used to produce electricity." Not one biomass facility qualified. Crops are rarely, if ever, grown for single-product markets on long-term contracts.

In 1999, Congress made a similar error by offering a handsome incentive only for the generation of electricity from manure. Poultry manure is an attractive organic fertilizer. It is high in nitrogen, dry, and relatively easy to store and transport. The rapid growth of the organic foods market has increased the demand for organic fertilizers. Incentives offered by state and federal governments to poultry growers can be as high as $25 per ton of manure, but only if electricity is produced.

As a result, millions of tons of nitrogen and valuable soil-building tilth could be destroyed, undermining soil health and requiring the manufacture of nitrogen fertilizers, a very energy-intensive process.

Dispersed ownership spurs innovation and attracts farmer participation

A major expansion of the use of plant matter for nonfood and feed purposes could result in hundreds, even thousands, of new processing and manufacturing facilities in rural America. This development in and of itself would benefit rural communities. But the level of benefit gained would depend, to a significant degree, on the scale and ownership structure of those new facilities.

A proliferation of modestly scaled production enterprises will encourage competition, innovation, and cost reduction, while promoting healthy communities and strong local economies.

A proliferation of modestly scaled production enterprises also can address one of agriculture's most intractable problems: expanded markets do not inevitably translate into higher income for farmers and rural communities.

To achieve that goal, farmers must receive a portion of the profits earned beyond the farm gate. Consider, for example, the differential impact of an expanded market for ethanol on farmers who simply sell their corn to an ethanol facility, compared to farmers who own the ethanol production facility. Farmers who simply sell their corn might see an 10 cent per bushel increase because of the overall impact higher demand has on corn prices. Farmers who are owners of the ethanol facility will not only enjoy these same higher prices but can receive an annual dividend of 25-75 cents a bushel. Indeed, in 2000, many farmer-shareholders in an ethanol plant received almost as much in dividends as they did for their corn on a per bushel basis.

Recognizing this dynamic, Minnesota policy makers in the late 1980s changed the state ethanol incentive into a direct payment for in-state production for the first 15 million gallons a year produced. An expansion of small and medium-sized ethanol plants followed. Many of these are owned by more than 8,000 Minnesota farmers.

Today the nation boasts more than 100 farmer-owned plants. All are less than 25 years old. Most are less than 10 years old. Public policy at the federal and state level should support such ownership forms as a way of maximizing the benefit of expanding biomass consumption to rural areas and the farmers.

One way to achieve this would be to favor farmer-owned facilities in federal incentive programs. Another way would be to require that any technologies developed as a result of federal R&D spending must be licensed at reasonable cost to farmer-owned cooperatives.

Scale matters

As was noted above, a proliferation of producers leads to innovation and enhances the civic and economic health of communities. To enable this proliferation, federal and state governments should encourage smaller scale operations. Minnesota's ethanol production payment limitation to the first 15 million gallons produced per facility is an example. The Commodity Credit Corporation, in distributing surplus corn to ethanol plants that are expanding production last year and this year, designed a higher incentive for smaller plants.

The federal government should investigate whether some R&D techniques lend themselves to more dispersed applications. At this point the information on this is skimpy, but the experience with organic agriculture demonstrates that needed research can change dramatically when social or environmental impacts are taken into account.

The combined orientation toward smaller and more locally owned production facilities can inform many areas of public policy. For example, the federal government has invested tens of millions of dollars in commercializing the cellulose-to-ethanol process. To date, the focus has been on building greenfield facilities. This requires not only that the technical process be new but that the rest of the facility's operations be new. It might be better to focus on adding a cellulose-to-ethanol stage onto an existing starch-to-ethanol plant. That way the management, marketing, engineering know-how, and infrastructure are already in place. Some estimates are that the cost of constructing three such facilities would be about $60 million. A provision of any public investment would be that the know-how developed would be shared with other biofuel facilities.

Often, federal incentives and R&D funds move in the opposite direction, favoring absentee- owned, large-scale, centralized facilities. This may be the case in public expenditures on animal manure digesters. In dispersed animal feeding operations, manure inexorably becomes a fertilizer. Concentrated animal feeding operations concentrate the manure, creating both an environmental problem and an opportunity for electricity generation. The federal government should be cautious about providing incentives that favor a specific kind of agricultural structure.

Inside genetic engineering should have a priority over outside genetic engineering

Of the total federal R&D budget for biomass, the largest single expenditure, $33-$53 million, is devoted to genetic engineering. There is worldwide debate regarding genetically engineered crops. Opponents worry about the loss of farmer autonomy and potential environmental contamination. To address that debate, it might be useful for policymakers to distinguish between different kinds of genetic engineering.

There are two distinct research areas within the genomic budget. One we might call "inside" genomics: that is, genetic engineering of microorganisms to improve productivity inside the manufacturing plant. The other, "outside" genomics, is the genetic engineering of plants in the field.

Money spent on enzymatic advances to lower the cost of converting corn sugars into plastics is an example of "inside" genomics. Spending money to redesign corn itself so that it produces plastics is an example of "outside" genomics. Federal departments currently fund both types of genomic research. They make little or no distinction between them. They should.

"Inside" genomics offers dramatic benefits: a reduction in production costs of 40-90 percent, an increase in yields of several orders of magnitude, and a dramatic reduction in environmental pollution. The downside risk of "inside" genomics is very low.

The benefits of "outside" or field genomics, on the other hand, appear modest. The National Center for Food and Agricultural Policy, an industry organization strongly in favor of genetically engineered crops, released a study on the subject last April. It concluded that genetically engineered Roundup Ready soybeans, for example, have the same yield and require the same volume of chemicals to kill weeds as traditional varieties.

The risk of "outside" genomics is catastrophic environmental contamination.

There is another important difference between inside and outside genomics. There is rarely an alternative biological strategy to inside genomics. When it comes to genetic engineering in the field, however, there is. For example, the publication Nature reports that in China the planting of a wide variety of breeds of rice resulted in a 94 percent reduction of rice blast, a devastating fungus that normally requires repeated applications of pesticides to control. Yields increased by 18 percent when compared with fields containing a homogeneous genetic monoculture. In 1997, only a few acres were planted. In 2000, this grew to 150,000.

Finally, inside genomics does not appear to pose a risk to alternative manufacturing techniques. But outside genomics can pose a risk to alternative farming techniques. Organic farmers worry that they will lose their organic certification if genetically engineered crops from a neighbor's field pollinate their own.

The dramatically different dynamics and cost-benefit ratios of inside and outside genomics research argue for a reallocation of resource expenditures from the latter to the former.

Nonexclusive publicly funded research may be superior to exclusive licensing

In 1980, Congress gave the Executive Branch permission to offer exclusive licenses to private companies to use research developed with public funds. Much of the research in the departments of Energy and Agriculture now is done under this arrangement. It is time for the federal government to evaluate whether this shift has been beneficial. Based on evaluations of the Department of Agriculture's research programs, the shift may have been detrimental, although there appears a dearth of studies that compare the different strategies in terms of their effectiveness at commercializing the knowledge created.[3]

Conclusion

There is a vast potential for using carbohydrates to replace hydrocarbons. An embryonic management and entrepreneurial infrastructure is in place. Federal and state policymakers recognize that the increased use of plants for nonfood and feed purposes can achieve multiple objectives, including enhanced national security.

Currently the federal biomass program is fragmented among several agencies and many departments. There is relatively little coordination among R&D initiatives. The symbiotic and potentially reinforcing relationship of R&D to other public policy tools is little exploited. R&D focuses overwhelmingly on engineering, with little attention paid to attracting farmer participation. The scale and ownership structure of manufacturing plants is rarely if ever taken into account, thus reinforcing the disconnect between expanded consumption of crops and the well-being of rural communities.

[3]For more in-depth discussion, see David Morris, *Technology Transfer and the Agricultural Research Service*. Report to the Undersecretary of Research and Education of USDA. July 1996.