

Designing an Effective Federal Biomass Program

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Abstract

This paper addresses two questions. Has the effectiveness of federal R&D spending suffered from the post 1980 strategic change from freely shared and publicly owned to privately owned scientific advances? What criteria would a federal R&D program use to design a strategy that most effectively enhances the well-being of farmers and rural communities? Several studies found that the pre-1980 USDA research strategy was very effective. No comparable

studies have analyzed the comparative effectiveness of the post 1980 strategy of restricting access to the results of public research. Recent experience and several analytical studies suggest that to significantly enhance the health of rural economies from an expanded use of plant matter as an industrial material federal policy should channel scientific and engineering research into small and medium sized production and processing technologies and policy should encourage farmer-owned value-added enterprises.

Keywords: ethanol, scale, ownership, R&D, effectiveness

Introduction

One of the 20th century's greatest scientists and thinkers Albert Einstein observed, "Perfection of means and confusion of ends seem to characterize our society". Are our federal programs supporting industrial uses of biomass an example of such thinking?

The ends of the federal biomass programs are clear enough: enhanced national security, improved environmental protection, stronger rural economies. Research is a means

to these ends. Are the federal biomass programs designed to most effectively achieve these ends?

Federal programs and policies channel scientific genius and entrepreneurial energy and investment capital in specific directions. With regard to biomass, the overall impact of direct spending and tax incentives is not insubstantial.

The federal government spends over \$200 million a year directly on R&D directed toward expanding industrial uses of biomass. Assuming a three to one average private to public investment match, this federal direct spending attracts an additional \$600 million in private spending. Federal biomass-related tax incentives presently “spend” over \$1 billion a year. This in turn attracts several billion dollars of private investment in these areas. The vast majority at present goes into expanding ethanol production.

This paper examines some aspects of federal R&D efforts in the biomass area. It raises two questions. One is whether the post-1980 changes in the way the federal government conducts biomass research has made the biomass R&D effort more or less effective in achieving its stated goals.

The observations are primarily directed toward the Department of Agriculture because the vast majority of its research is conducted in-house by permanent scientific staff.

The second question focuses on one of those goals, improving the well-being of America's farmers and rural communities, and suggests that social criteria can and should inform and guide engineering research strategies.

The observations are primarily directed toward the Department of Energy, although they are broadly applicable to agency heads and policymakers.

Public vs. Private Knowledge

Before 1980 the results of federal agricultural research were freely available and widely shared. Virtually all of the research was directed toward improving crop production and yields and improving harvesting and storage costs of crops intended for food and feed markets.

There are considerable uncertainties regarding cost-benefit analyses. Nevertheless, it is instructive that the many studies done both inside and outside the United States

Department of Agriculture(USDA) found its pre-1980 R&D efforts very effective and influential.

USDA economists found that publicly funded agricultural research earned an annual rate of return of at least 35 percent.¹ A 1966 study by the Agricultural Research Service(ARS) of the impact of its research from 1941-1966 concluded that 109 products and processes developed by ARS had been commercialized and 26 represented major contributions in basic research. Their value was estimated by the ARS at over \$6 billion, 20 times the \$309 million spent by the ARS labs during this period.²

A 1980 study by the Congressional Office of Technology Assessment of the benefits stemming from agricultural research concluded, “the range of estimated rates of return is from a low of 23 percent to a high of 100 percent”.³ A 1992 study by Chapman and Associates examined 178 cases of ARS research projects completed from 1980 to 1990 (including cooperative programs or joint programs with State Agricultural Experiment Stations). Of the 178 cases, benefits data were identified for 87, resulting in \$14.8 billion

in sales or savings. These savings were greater than the total amount spent on the ARS during that time period.⁴

Another study found that although the ARS had a relatively small number of patents compared to the private sector in agricultural related areas, the ARS patents were cited more often than private patents. Thus the ARS patents were considered more often "key" patents marking significant advances in knowledge.⁵

Despite these successes, in the late 1970s there was a growing and increasingly influential school of thought that a focus on more basic research and the nonexclusive sharing of the fruits of such research was not encouraging the levels of private investment sufficient to commercialize new technologies. Many potentially valuable scientific advances thus were remaining in the labs. Commercialization would occur only if private investors could be guaranteed exclusive access to the knowledge generated from what would increasingly become investments in federal research efforts made by both private and public sectors.

In rapid fashion, beginning in 1980, the federal government dramatically changed its R&D strategies to encourage one in which private interests became increasingly influential in directly and assisting public research.

- The University and Small Business Patent Procedure Act, commonly known as the Bayh-Dole Act of 1980, gave non-profit organizations such as universities as well as small businesses the right to retain patents for technology developed with government funds.

- The Stevenson-Wydler Technology Innovation Act of 1980 provided federal departments, agencies, and affiliated laboratories with a legislative mandate to pursue technology transfer activities. Each agency was to make available not less than 9.5 percent of its R&D budget for technology transfer activities.

- In 1983 an Executive Order extended the coverage of the Bayh-Dole Act to all government contractors. The Act also granted federal agencies the right to offer exclusive or co-exclusive licenses to patents on inventions made by lab

employees when considered necessary for the commercialization of the invention.

- The Federal Technology Transfer Act of 1986 allowed federal labs to enter into Cooperative Research and Development Agreements (CRADAs) with private firms. A CRADA confers two important rights to businesses: 1) the right of first refusal of an exclusive license on any patentable inventions that arise from the research partnership; 2) the right to keep research findings secret for five years. The Act also permitted royalty income from patent licensing and assignment to be distributed directly to the inventors. The 1986 Act also made technology transfer a responsibility of every laboratory scientist and engineer. It required at least one full time equivalent technology transfer position for every laboratory having 200 or more full time scientific, engineering and related positions.

Today much if not most federal research, including biomass-related research, is done in partnership with private companies that have the right to exclusively own the intellectual property generated from that collaboration.

How effective has been the post 1980 approach compared to its predecessor?

Unfortunately, there are few if any studies that adequately address this important question. Vast changes in agricultural technologies have occurred over the last 20 years, especially in the area of biotechnology in crops and animals. Yet in this area federal R&D spending may have played a modest role that largely followed the massive amounts of venture capital that flowed into the biotech sector.

Efforts to compare the pre and post 1980 R&D strategies are confounded by the fact that the metrics used to evaluate the performance of federal research have changed. In the older period the measures used largely reflected the impact on the country and the countryside, e.g. the number of acres planted in the new hybrid, the rate of adoption of a new technology by farmers or processors. The new approach largely measures the impact on the agency or its private partner(e.g. number of patents issued, number of licenses issued, amount of royalties received).

It is now over twenty years since the federal government adopted a dramatically different approach to research and development by emphasizing technology transfer, private partnerships and exclusive licensing. This is sufficient time to allow us to evaluate the comparative effectiveness of both approaches.

The impact of federal biomass R&D on rural communities

One of the principal objectives of the federal biomass program is to improve the lot of farmers and rural communities. History teaches us that simply expanding demand for plant matter will not automatically benefit the cultivators of that plant matter. 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."⁶

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.⁷

What this means is that for the farmer to significantly benefit from federal biomass policies these policies must enable the farmers to gain an income from the value-added steps in converting the commodity crop into a wholesale and retail product.

I serve on a congressionally created Committee that advises the Secretaries of Energy and Agriculture on biomass research and development efforts. In 2002 the Biomass R&D Technical Advisory Committee delivered its first annual report which acknowledged, "Expanding the use of biomass for non-food and feed purposes will benefit farmers and rural areas only indirectly and modestly. A more significant

development would occur if farmers themselves were able to produce the biofuels or bioproducts, either on the farm or as owners in a local production plant.”⁸

Consider the emergence of bioethanol as an instructive example. The federal excise exemption for ethanol plus Clean Air Act regulations has created a 2.5 billion gallon per year ethanol industry. Evidence from Minnesota and Missouri indicates that this has increased the price that farmers are getting for their corn from local ethanol plants by 5-10 cents per bushel.⁹

However, if farmers own the ethanol plant they receive the additional price that results from increased markets plus they receive a part of the profit generated at the manufacturing level. Information on returns on ethanol investments is closely guarded and the returns vary dramatically from year to year and from plant to plant. Nevertheless, it is not unusual for the dividend in an average year to be 25-50 cents per bushel. One unreleased study of the farmer-owned Minnesota Corn Processors ethanol plant found that farmer-investors earned about 18 percent annually over the 20 year life of the plant as a cooperative.

Scale: The Minnesota Lesson

Unlike the federal government, several states have altered their biomass incentives to enhance the positive impact on rural communities. The Minnesota experience, often called the Minnesota Model, is instructive.

In the early 1980s Minnesota's state ethanol incentive mirrored that of the federal incentive—a partial exemption from the gasoline tax. That incentive succeeded in making the price of ethanol competitive with other gasoline additives. The demand for ethanol blended gasoline soared. But the demand was met entirely by ethanol imported into the state from out of state large manufacturing facilities owned by one multinational corporation. Minnesota farmers and Minnesota's farming communities did not benefit from the expanded consumption of ethanol inside the state.

To remedy this problem, in the mid 1980s Minnesota converted its state ethanol incentive from a consumer-oriented excise tax exemption to a producer-oriented direct payment. Instead of reducing state gasoline taxes by a

couple of pennies for a 10 percent ethanol blend, the state paid 20 cents a gallon for ethanol produced within the state. To encourage the construction of many plants in different parts of the state the incentive, which ran for 10 years, applied only to the first 15 million gallons produced.

Some argued that by encouraging many small biorefineries the government was encouraging higher-cost and more inefficient biorefineries because of the engineering economies of scale involved. Indeed, an internal study by the Institute for Local Self-Reliance concluded that a 150 million gallon per year ethanol facility had unit costs about 15-20 cents per gallon less than those of a 15 gallon per year facility.

Thus the 20 cent incentive made up for the difference between small and large. The result was that rather than one or two 100 million gallon plants by 2002 Minnesota was home to 15 ethanol plants, the average capacity of which was 15 million gallons per year. The scale of the plants also encouraged farmer ownership. In 2002, 12 of the 15 plants were owned by over 9000 grain farmers. These provided almost 10 percent of the transportation fuel sold in the state.

The proliferation of small plants led to an unanticipated technological dynamic. Because of the large number of plants built, several engineering firms competed with each other to design and build the least expensive and most efficient facility. Yields of ethanol in dry mills quickly rose from 2.5 to over 2.8 gallons per bushel. The large number of plants, coupled with equal numbers of plants being built in surrounding states accelerated the engineering and operational learning curves.

The result was to rapidly reduce the cost of ethanol produced from small dry mills. Indeed, a 1998 study by USDA that examined the comparative economics of small and medium sized dry mills and large wet mills. The 1998 survey was a follow-up to a 1987 ethanol plant survey.

In 1987 small and mid sized dry mills had cash operating costs of 50 cents per gallon. Large wet mills had a cash operating cost of 47 cents per gallon. By 1998 dry mills had dropped their operating costs to 41.7 cents while wet mills had dropped theirs only marginally, from 47.2 cents to 46 cents,. The 1998 report concluded, "Wet mill variable costs

appear to have remained very stable at about 46 cents per gallon. Improved energy cost management was offset by several factors, including waste management and overhead...In contrast, dry mills have experienced a 15-percent reduction in operating costs, due to the effects of reduced energy, labor and maintenance expenditures and possibly economy of scale.”¹⁰

Scale

Can federal research efforts focus on technologies applicable for smaller facilities? What would such research look like? This is a key challenge for researchers and policy makers. Engineering economies of scale do exist, as do management and marketing economies of scale. However, there are technologies that lend themselves more to modular expansion. Technologies should as much as possible allow the farmer to capture the value added from storing, preprocessing and perhaps even processing the crop on site.

In the late 1970s, the Department of Energy launched its wind energy initiative. Wind energy has dramatic economies

of scale. The power output varies by the square of the diameter of the blades and by the cube of the increase in the wind speed. DOE focused on building very large diameter wind turbines. These mega-turbines contributed relatively little to the technological advances in the wind energy field. Much more important for wind energy development was the design of buyback tariff structures in California in the early 1980s and the wind energy mandate in Minnesota in the mid 1990s.

As the wind energy industry grew, advances in the electronics and construction design of wind turbines grew even more rapidly. As they did wind turbines became larger in a more organic way, moving from the 200 kw machines of the early 1980s to the 750kw machines of the late 1990s to the new 1.5 MW machines.

In 2001, DOE launched a small wind turbine initiative. The objective was to make wind energy economical in the many areas of the country that have lower wind speeds. It is a 180 degree turn from the wind energy program of the late 1970s. It is too early to evaluate its results.

In the biomass area the Department of Energy favors larger facilities, again because of their engineering economies of scale. The biomass program's orientation to the scale of production systems mirrors that of the fossil fuel and nuclear programs. Yet biomass has characteristics that may lend itself to a different orientation. The cost of transporting biomass, for example, is much higher than the cost of transporting fossil fuels or uranium. And the farmer-oriented and rural economy objectives of the biomass program are not part of the fossil fuel or nuclear development program.

Both the Department of Energy and the Department of Agriculture are conducting research in biochemical production. How would a focus on smaller scale and modular production units affect the research done under these programs?

The Department of Energy and to a lesser extent, the Department of Agriculture, have largely ignored questions of scale and ownership in their research and development efforts. The result could be that a success in dramatically increasing the use of biomass for energy and industrial purposes may well not translate into higher farmer income or

healthier rural communities. Yet these are formal objectives of both agencies' missions. Taking these socioeconomic factors into account could well encourage a different R&D and commercialization strategy by the federal agencies in charge of the biomass program.

Footnotes

¹ Catherine E. Woteki, Deputy Undersecretary, Research, Education and Economics, USDA, Testimony Before the House Agriculture Committee, Resource Conservation, Research and Forestry Subcommittee, May 14, 1996

² *Achievements in Agricultural Utilization Research*, ARS Committee on Research Achievements, ARS, Washington, DC, November 1966. The same 25 year period, 1941-1966 was examined in a Ph.D. thesis at the University of Georgia by Harold B. Jones, Jr., of the USDA's Economic Research Service. He found that 9 percent of the projects undertaken by the regional labs by 1966 had produced an economic return. That figure compared favorably with returns on food industry research. The cost-benefit ratio was 20 to 1 or better. (cited in *Always Something New: A Cavalcade of Scientific Discovery*, USDA, Agricultural Research Service, Miscellaneous Publication 1507. November 1993.

³ Fred C. White, et. al, "Nature and Flow of Benefits from Ag-Food Research", *An Assessment of the United States Food and Agricultural Research System*. Volume 2. *Commissioned Papers, IR-6 Information Report No. 5*. Office of Technology Assessment, Washington, DC, December 1980, pp. vii-x.

⁴ Chapman and Associates, *An Exploration of Benefits from ARS and Cooperative Research*, Littleton, Colorado, June 12, 1992.

⁵ Editors, S. Ramanujam, et al. *Science and agriculture : M.S. Swaminathan and the movement for self-reliance*. Arid Zone Research Association of India. New Delhi. 1980.

⁶ Speech by Senator John F. Kennedy at the National Plowing Contest. Sioux Falls, South Dakota, September 22, 1960.

⁷ David M. Russo and Edward McLaughlin, *Farmers Can Get Bigger Share of Food Dollar*. New York State College of Agriculture and Life Sciences, Cornell University, April 1991 estimates the retail price of corn flakes at \$1.56 per 18 ounce box. Corn represents about 10 cents of the cost. The Economic Research Service, in *Food marketing and price spreads: farm-to-retail price spreads for individual food items*, 2003, estimates the year 2000 cost of an 18 ounce box of corn flakes at \$2.14 and corn flakes representing 8 cents of the cost.

⁸ *Biomass RoadMap*. Biomass Research and Development Technical Advisory Committee. November 2002. Washington, D.C.

⁹ Personal communication from several ethanol plant managers in Minnesota. Also see Van Dyne, D. L. *Employment and Economic Benefits of Ethanol Production in Missouri*. Department of Agricultural Economics., University of Missouri-Columbia, February 2002.

¹⁰ Hosein Shapouri, Paul Gallagher and Michael S. Graboski, *USDA's 1998 Ethanol Cost-of-Production Survey*. USDA. Washington, D.C. 1998.