Agriculture as a Producer and Consumer of Energy

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USDA's Office of Energy Policy and New Uses

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MISSION STATEMENT

The Office of Energy Policy and New Uses (OEPNU) assists the Secretary of Agriculture in developing Departmental policies, programs, and strategies related to energy and biobased products. The Office coordinates USDA activities related to energy and biobased products within and outside the Department. The Office conducts economic analysis and evaluates policies concerning energy and the utilization of biobased products. Research is currently underway on producing renewable fuels and biopower from biomass and marketing biobased products. The Office is also involved in tracking energy use trends on crop and livestock farms.

The Office of Energy Policy and New Uses has the lead role in implementing sections 9002, 9004, and 9007, Title IV, of the Farm Security Rural Investment Act of 2002. Section 9002 provides for the preferred procurement of biobased products by Federal agencies. Section 9004 provides funding for USDA's Biodiesel Fuel Education Program. Section 9007 instructs USDA and the Department of Energy to enter into a MOU establishing a joint program for the application of hydrogen and fuel cell technology. OEPNU is with the Office of the Chief Economist, located at 300 7th Street, S.W. Room 361, Washington D.C. 20024. Roger Conway, Director, can be reached at (202) 401-0461 or Rconway@oce.usda.gov.

Farm Foundation

www.farmfoundation.org

Farm Foundation is a publicly supported non-profit organization working to improve the economic and social well-being of U.S. agriculture, the food system and rural communities by helping private and public sector decision makers identify and understand forces that will shape the future.

Serving as a catalyst, Farm Foundation partners with private and public sector stakeholders, sponsoring conferences and workshops to explore forces shaping the competitiveness of agriculture and the food system; encouraging application of research results to increase human capital; promoting informed dialogue on public issues and policies; and building knowledge-based networks for U.S. agriculture and rural people.

Farm Foundation does not lobby, nor advocate positions. Its 70-year reputation for objectivity allows it to bring together diverse stakeholders for quality discussions on issues and policies, providing a solid basis for informed private and public-sector decisions.

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EXECUTIVE SUMMARY

Introduction

Recent concerns about energy security have focused greater attention on agriculture's role as a producer and consumer of energy. The prices for oil and natural gas, two of U.S. agriculture's principal energy sources, are going through a period of unprecedented volatility. In 1999, crude oil prices were at their lowest real (inflation adjusted) level since the early 1970s and reached their highest real price levels since the late-1970s in 2004. This price swing has been influenced by fears of terrorism and rising oil demand in the world.

Until the late-1990s, natural gas production capacity in North America exceeded demand. As natural gas production leveled off, demand grew for electric power generation and other uses. Both the world oil market and the North American natural gas market appear set to remain at higher real price levels for the next several years.

With the United States the world's dominant consumer of energy, policymakers are searching for ways to expand domestic energy sources through development of alternative fuels and energy-saving technologies. Since the 1970s, federal and state energy polices have played a major role in encouraging renewable energy production. For example, the primary goals of the *National Energy Act of 1978* and the *Energy Policy Act of 1992* were to increase the domestic production of alternative fuels to help reduce dependence on foreign oil. More recently, the President's National Energy Policy Group advocated the use of federal programs to promote alternative fuels, such as ethanol and biodiesel, to help reduce U.S. reliance on oil-based fuels. Legislation has also been passed to encourage energy conservation by setting fuel efficiency standards for the automobile industry and adopting building energy-efficiency standards for government buildings.

Environmental policies, such as the *Clean Air Act Amendments of 1990*, have also had a major influence on the demand for renewable energy, since fuels made from renewable sources tend to be cleaner burning and less toxic than petroleum-based fuels. The *Farm Security and Rural Investment Act of 2002* — the first farm bill to include an energy title—is aimed at expand-

Agriculture as a Producer of Energy

A century ago, agriculture played a much larger role in producing the nation's energy supply. In the early 1900s, farms provided much of the fuel, in the form of grain and hay, fed to animals that provided the nation's transportation needs, and much of the wood used for heating and cooking. In 2001, of the 97.1 quadrillion British thermal unit (Btu) of energy consumed in the United States, 39 percent were petroleum-based products, 24 percent were natural gas, 23 percent were coal, 8.2 percent were nuclear, and 5.8 percent were renewable energy sources. Of the renewable energy sources consumed, 41 percent was produced through hydropower, and 39 percent was the burning of wood. Ethanol, biodiesel and windpower made up only 0.21 percent of the energy consumed in the United States in 2001. More recent data indicate that biomass has overtaken hyrdopower as the leading source of renewable energy in the United States.

While modest, the production of ethanol, biodiesel and electricity generated from wind turbines has been increasing rapidly. Ethanol production has nearly doubled from 1,470 million gallons produced in the United States in 1999 to 2,810 million gallons in 2003. Biodiesel production increased over the same period from 500,000 gallons to 20 million gallons. Likewise, electricity produced from windpower has increased from 4.5 million megawatt hours in 1999 to 10.5 million megawatt hours in 2004.

Several emerging technologies, such as anaerobic digesters which convert animal wastes to methane gas, and new ways to produce ethanol and bioproducts from biomass, offer additional ways in which agriculture can contribute to the nation's energy supply.

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ing renewable energy supplies and increasing energy efficiency on U.S. farms.

In cooperation with the Farm Foundation, USDA's Office of Energy Policy and New Uses organized the conference "Agriculture as a Producer and Consumer of Energy," which was June 24-25, 2004, in Crystal City, VA. It brought together industry experts, economists, government leaders and others to gather baseline information and identify agriculture's role in solving our nation's energy problems. This publication summarizes the conference presentations.

Looking Forward

As a source of energy, agriculture cannot be expected to completely meet the United States' energy needs, but it can make an important difference as part of a portfolio of diverse energy sources. Agriculture's greatest untapped potential opportunities appear to be with biomass. With biotechnology and other new and emerging technological processes, agriculture biomass not only has the potential to be a source of biofuels and other energy, but also a source of chemicals and materials that can substitute for fossil-based energy inputs in a range of processed products. For agriculture to realize these opportunities, the economics of production, distribution and use will have to continue to improve relative to fossil fuels. As economic feasibility evolves, utilizing biomass resources can contribute to greater energy security, a cleaner environment and a stronger rural America.

Along with biomass, other forms of alternative energy, such as wind, solar, and geothermal power are also beginning to emerge as new sources of domestic energy. Largely due to technological advancements, the production of these alternative energy sources has increased significantly over the past two decades. Government incentives and high energy prices will continue to encourage investment in new technologies that could greatly increase the potential to produce a wide variety of new domestic energy sources. Together these fuels can help expand the domestic energy supply and increase the country's energy independence.

Significant growth in renewable energy sources will depend partially on government assistance. Some policymakers have been very critical of renewable fuel subsidies, such as the ethanol fuel tax credit, currently $0.51 per gallon. They argue that the free market can solve our energy problems.

Agriculture as a Consumer of Energy

The U.S. farm production consumes energy sources directly through diesel fuel, gasoline, natural gas and liquid petroleum gas used largely for planting, tillage, harvesting, drying and transportation. Electricity consumption, also classified as direct energy, is primarily used for irrigation, climate control in livestock facilities, and dairy operations. Indirect energy is used off the farm in producing inputs that are ultimately consumed on the farm. Some indirect energy-intensive farm inputs include pesticides and commercial fertilizers, which can use large amounts of energy in their production.

When considering both direct and indirect energy consumption, farm production used approximately 1.7 quadrillion Btu, or 1.7 percent of total energy consumed in the United States in 2002. U.S. farmers consume about one percent of U.S. motor gasoline and six percent of diesel and other distillate fuel. On-farm operations accounted for about 2.3 percent of liquid petroleum (LP) gas, 0.25 percent of natural gas, and about one percent of electricity consumed in the United States in 2002. In addition to on-farm energy consumption, substantial amounts of energy are consumed off-farm in processing and handling food.

In 2002, direct energy use on farms accounted for twice as many Btu as indirect energy, but direct energy accounted for 3 percent to 4 percent of total farm production expenditures, while indirect energy accounted for 9 percent to 10 percent of expenditures.

The cost of producing ethanol from corn, estimated by USDA at $1.60 per gallon in the mid-1980s, steadily declined to the low $0.90s per gallon by the late-1990s.

However, almost all forms of fossil energy produced in the United States have enjoyed some form of government subsidies. Without government support, renewable fuels would not be competing on a level playing field. In addition, the higher cost of renewable fuels production does not reflect the environmental and energy security benefits of replacing petroleum fuels. More research is needed to quantify the non-monetary value of renewable fuels to help policymakers determine the appropriate level of public support for renewable fuel programs.

Fitting Biomass Energy from Agriculture into U.S. Energy Systems

The energy sources the nation uses are determined when an energy *form* accomplishes what is needed at a particular *time* and at a specific *place*. As technology changed, these requirements were better met by an evolving energy infrastructure, which used liquid petroleum-based fuels for transportation and fossil fuels for energy, instead of the once predominate use of hay to fuel animals providing transportation needs and wood to provide heat and light.

Ethanol and biodiesel are growing fuels because they have been able to fit into the form, time and place requirements of the present energy system. For example, one of the initial concerns about ethanol was its water-absorbing characteristic, which created difficulty in transportation and storage. Equipment modifications and process changes have eliminated that problem. As a renewable energy source, ethanol is available in a timely fashion. Its form, given the nature of the blend, is for practical purposes the same as the existing petroleum-based gasoline. Ethanol is distributed across the same geography as its counterpart gasoline using the same retail delivery infrastructure. Reliability of product supply, performance and quality are no longer seriously questioned by users. One would expect that biodiesel could follow a similar path.

Ethanol has not been without controversy. For more than 30 years, there has been a scientific debate as to whether ethanol requires more energy to produce than its caloric yield as a fuel. If one takes a form, time and place energy systems perspective on this argument over ethanol's energy balance, it becomes a much less important dispute. A reason to produce ethanol is to address a scarcity of liquid fuel on which much of our transportation system depends. If energy that is in abundance but is not in liquid form is converted to a liquid form, the scarcity can be resolved, even if it takes more energy in solid or gas form than is contained in the liquid form.

Transformation of corn to liquid fuel, despite high cost, has increased because of environmental regulation, federal and state government support, and improvements in production efficiency. Efficiency improvements have also been important in maintaining the public financial and research support for biofuels. For example, the cost of producing ethanol from corn, estimated by USDA at $1.60 per gallon (nominal dollars) in the mid-1980s,

Glossary

Biodiesel is an oxygenated fuel made from vegetable oils, animal fats or recycled fats.

Biomass is biological material such as grains, wood, wood residues, animal wastes and grasses; which can be processed into fuels, such as ethanol or biodiesel, or used to generate electricity.

Ethanol, or ethyl alcohol, is predominately used as an oxygenate (an octane enhancing fuel additive) in gasoline. It may be produced from grain, sugar cane, sugar beets, leafy or woody plant material, or food and beverage

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steadily declined to the low $0.90s per gallon by the late-1990s.

Producing ethanol only from corn has limits. Converting a 10 billion bushel corn crop (a rough approximation of our annual production over the last decade) to ethanol would yield approximately 27 billion gallons of ethanol, roughly 19 percent of U.S. gasoline use. Such a conversion of the whole corn crop to ethanol would replace about 14 percent of total oil imports, a significant contribution to energy security, but there would be no corn for our livestock industry or for corn exports, an untenable outcome.

Electricity is another great energy need. Conversion of agricultural biomass into electricity has been explored using methane or gasified biomass solids, burning biomass solids directly, and co-firing wood waste and switchgrass with traditional (boiler) fuels such as coal. Agricultural biomass is renewable and available. Yet, the major hindrance is a lack of electrical plants and transmission infrastructure in the locations where agricultural biomass is most available.

The United States' energy system reflects form, time and place. Consequently, any new energy sources or systems have to be viewed to the extent that they conform to meet the perceived needs that are already met by the existing systems. The critical question is, when and under what conditions might some of the form, time and place bounds be broken, providing greater flexibility about fuels and energy use?

For More Information

A book developed from the major conference presentations and cutting-edge research presented at the conference is being published by CAB International. Contact Steve Halbrook at Farm Foundation [(630) 571-9393 steve@farmfoundation.org] for more information. Additional conference materials are available online at *http://www.farmfoundation.org/projects/03-35AgAsEnergyProducerAndConsumer.htm*.

Research and Data Needs Identified by Conference Participants

- Develop renewable fuels and increase energy efficiency on agricultural operations.
- Evaluate technologies aimed at reducing the costs of producing renewable fuels.
- Explore new uses for co-products and create more value-added opportunities for renewable fuels.
- Investigate the economics of the "biorefinery concept."
- Examine the logistics of integrating renewable fuels into the current U.S. petroleum distribution system.
- Estimate the non-monetary value of renewable energy.
- Analyze the role of other crops and imports of vegetable oil as feedstocks for biodiesel.
- Research the roles of imports and exports in the development of the biofuels industry.
- Investigate the economic feasibility of biorefining.
- Complete a more integrated analysis of the amount of ethanol from grain, biodiesel and lignocellulosic biomass that would be supplied at various price levels and update this periodically.
- Develop data needed to help evaluate energy use and develop energy-saving strategies for livestock facilities, dairies, nurseries and greenhouses.

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Research Topics Presented at the Conference

- ***Economic Viability of Ethanol and Biodiesel*** – While ethanol and biodiesel production have been technologically feasible for a number of decades, they have benefited from subsidies and other promoting policies like other energy sources. Five economic studies examined the future viability of biofuels:
  - o An analysis of the economic factors associated with success or failure of dry-mill ethanol plants utilizing corn as a feedstock.
  - o An assessment of the expansion in ethanol and biodiesel production on major agricultural variables.
  - o A study was presented of the feasibility of constructing and operating a corn-based versus a sweet sorghum-based ethanol production facility in Texas.
  - o An economic model of a corn stover to ethanol industry in the Midwest.
  - o An economic modeling system that considers timing of harvest, storage, transportation and feedstock inventory management, for a lignocellulosic biomass biorefinery to determine the most economical feedstock sources.

- ***Energy Conservation and Efficiency in Agriculture*** – Although new production technologies can help meet energy needs, conservation and efficiency technologies are equally important.
  - o A report was presented on energy efficient water pumping systems for livestock.
  - o An analysis of a number of technologies which are being employed to reduce heating and ventilation costs in broiler houses was presented.

- ***New Methods and Technologies*** – New methods and technologies have the potential to utilize biomass resources in new ways.
  - o A presentation was made by a commercial energy company on its research concerning co-firing biomass in existing coal-fired power plants.
  - o A new strain of genetically engineered yeast which was developed for better ethanol fermentation was described.
  - o The potential uses for bioenergy and related products by rural electric cooperatives and the drivers for their purchasing decisions were discussed.
  - o The fuel properties of animal waste and different technologies for extracting energy, such as cofiring (mixing coal with animal waste) and thermal gasification of cattle manure and chicken litter, were discussed.

- ***Environmental Impacts and Considerations*** – Bioenergy can have both positive and negative environmental impacts.
  - o As more and more plants are used as raw materials for energy production, concerns are being raised about soil health and sustainability. The environmental impacts of various cropping systems were modeled.
  - o The results of an on-going study to estimate county supply (quantity, price, location) of corn, wheat, soybean, and other small grain residues as a function of environmental constraints (soil erosion, carbon, soil type, topology), management practices (tillage, crop rotations), technology constraints (machinery efficiency), geoclimatic factors, and economic factors were presented.
  - o A study was made of the impacts of greenhouse gas policy and associated carbon markets on the possibility of enhancing the competitiveness of biofuels.

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