Discussion Paper:
Recommendations for
Social, Economic, and Environmental Science Priorities for Bioenergy Research, Education, and Extension:
Results of the Joint USDA-DOE Experts Workshop on Bioenergy, Washington, DC, June 21-22, 2007

Table of Contents

Introduction

The USDA-DOE Bioenergy Experts Workshop has helped to identify the scientific foundations for sustainable bioenergy in the areas of social, economic and environmental sciences. The priorities articulated in this report provide a framework for potential research, education, extension and outreach activities at each agency, as well as areas for future collaboration between the two agencies. Furthermore, the priorities identified in this report extend beyond the missions of the USDA and DOE and suggest the value of even broader collaborations across the public and the private sectors to ensure long-term sustainability of bioenergy as a viable energy source.

With the recent surge of national and political support for the development of bioenergy alternatives to fossil fuels, some of the most important issues arising from the potential paradigm shift for agriculture and energy are the social, economic, and environmental implications of this surge in bioenergy production. The benefits of biofuels—lower carbon dioxide emissions; a renewable resource, a domestic feedstock supply; the revitalization of rural economies—have been widely reported, however complex interactions of a variety of factors ultimately determine whether a bioenergy options are sustainable—socially, economically, and environmentally. No single bioenergy “solution” can work for the entire country. Instead, a diverse portfolio of bioenergy options based on the local availability of biomass sources, land use competition, the structure of local agriculture, investment in infrastructure, feasibility of conversion technologies, environmental sensitivities, and geographic and cultural issues specific to communities must be considered.

Bioenergy research and development, which has largely focused on biophysical, engineering, and technological innovations, should understand the broader societal contexts that will influence and be affected by the application of these innovations. To address the social, economic, and environmental implications of bioenergy production, the U.S. Department of Agriculture (USDA) Cooperative State Research, Education, and Extension Service (CSREES) and U.S. Department of Energy (DOE) Office of Biological and Environmental Research (OBER) sponsored a workshop to identify and prioritize needs for research, education, and extension activities in each dimension (social, economic, and environmental) and at the intersection of these three dimensions. Recommendations from the diverse group of experts who attended this workshop will be used to inform both agencies on the priorities for federal investment in programs in research, education, and outreach.

Social Science Priorities

1. **Compare the relative merits—risks and opportunities—of different bioenergy development strategies for achieving such goals as: A) Rural economic development; B) Improved farm economy and agricultural producer well-being; C) Global climate change mitigation; D) Energy self-sufficiency; E) National security; and F) Sustainable biobased economies.** Feedstock production in rural areas will be enhanced if sufficient revenues from processing remain in these communities and help local economic development. One option is to promote local ownership of processing facilities; however, new technologies are risky and may require support from outside investors. Research is needed to analyze business structures, industry models, and risk-mitigation strategies for their impact on local communities. Improved regional models of farmer behavior also are needed to assess cultural differences that affect the transition to energy crops, acceptance of new business structures, involvement of minority farmers, and other issues.

2. **Research the effects of diversity and scalability in biomass feedstocks, conversion technologies, and biorefining systems to meet the needs of different communities**. Systems for cultivating and processing biomass feedstocks should have scalable components that can be designed to operate at different production levels. Small farms control two-thirds of land and farm assets, and these farms need to be engaged. Although economics and engineering may favor the development of large-scale systems, these systems are not an option for many communities constrained by climate, geography, feedstock supply, human resources, infrastructure, environmental restrictions, or other factors. Research is needed to study these issues.

3. **Through research, education, and extension activities, engage community leaders and facilitate local involvement at all levels of decision-making regarding social, economic, and environmental dimensions of bioenergy production.** There is a need for community engagement in informed decision-making and leadership that understands cultural norms, protects community interests, and successfully communicates development issues, tradeoffs, and benefits. Land grant universities can play an important supporting role in all states by providing access to education and outreach programs that not only raise awareness but also engage communities in collaborative discovery and dialogue. Open communication between industry leaders and community leaders will be critical to reaching a consensus on determining what scale of production is socially acceptable, clearly defining infrastructural and workforce needs, providing community input on siting biofuel production facilities, assessing appropriate risk levels, negotiating ownership options, identifying realistic returns from investments in bioenergy, and many other issues.

4. **Identify best practices for building community support for bioenergy production through historical and comparative analysis of similar and related industries and activities.** The recent momentum for developing cellulosic biofuels could be impacted by past experiences and unintended consequences of projects that affect public perceptions of alternative energy. For many bioenergy projects the social issues may be more difficult to address than the environmental issues. For example, plans for establishing a switchgrass-

based bioenergy facility in Virginia failed when farmers within a 20-mile radius of the facility would not agree to convert about half of existing cropland to switchgrass. Lessons learned from other related industries (e.g., contracts between the forest products industry and private landowners, business structures from other agricultural markets) could inform strategies for achieving community consensus for bioenergy production.

Economics Priorities

1. **Conduct detailed assessments of biomass resources**. Current knowledge of the U.S. biomass resource base is limited. To improve economic analyses, a better understanding of the quantity, heterogeneity, regional specificity, distribution, usability, logistical challenges, and costs of potential biomass resources, including forestry resources, is needed. Regional feedstock partnerships should be able to address many of these issues. Without sufficient knowledge of biomass resource availability and timelines for infrastructure development and technology adoption, policy analysis and full-cost accounting is difficult.

2. **Develop new economic models that consider a range of issues driving the growth of bioenergy markets**. Given multiple goals of economic growth, energy production, and environmental quality, new economic models are needed to evaluate a) a range of bioenergy technologies based on scenarios that reflect region-specific differences; b) competitive or synergistic uses of land and the biomass supply; c) better price valuation of energy crops based on energy content; d) potential policy incentives and mandates that are feedstock neutral and applicable to both large-scale and small-scale conversion technologies; e) analysis of input markets (e.g., farm machinery) and their ability to expand to meet bioenergy industry needs; f) standardized performance metrics derived from life-cycle analysis; g) bioenergy production within the context of carbon markets; and h) consideration of the relationship(s) of scale and economic viability.

3. **Analyze how different policy options may impact biomass production, biorefining capacity, bioenergy industry structure, trade and international markets**. Changes in U.S. agricultural production will impact both domestic and foreign markets for food, livestock feed, fiber, and fuel. For example, the use of genetically modified organisms or food security issues in other countries can impact the U.S. bioeconomy as well as foreign trade and international markets. In addition to global economic considerations, national and state policies will influence how components of a new bioenergy industry will develop in different parts of the United States. Subsidy policies, strategies for linking policy requirements to environmental incentives, laws affecting the formation of alternative business structures, and other policy issues will vary from state to state. Analysis is needed of policies and markets for both bioenergy and carbon sequestration, and their interactions.

Environmental Science Priorities

1. **Identify and examine the environmental consequences of land-use change resulting from increased biomass and bioenergy production.** If increased biomass feedstock

production results in the destruction of indigenous forests or other natural ecosystems, or displaces a land use that provides important ecological services as well as economic goods, the environmental costs of biomass production may become too great. We need to understand how large-scale changes in land use can affect greenhouse gas emissions, and how global warming will transform landscapes and impact agriculture. We need to identify the best strategies for ensuring a sustainable transition of land to bioenergy production. This analysis will require improved tools for quantifying the impacts of crop production practices at different geographic scales, on different farm types, with different soil and watershed characteristics.

2. **Compare the environmental impacts of monoculture crops versus a multi-species mix of biomass feedstocks.** Some of the reported advantages of using mixed species of biomass feedstocks rather than monocultures are increased and more consistent biomass yields, greater carbon sequestration in soils, enhanced biodiversity, increased resistance to pests and disease, and longer seasonal availability; however more research is needed to assess these various benefits in diverse biomass production systems. For example, it is not clear how the scale of production, regional variations in the timing of harvests, and the concentration of biomass production around biorefineries would affect biodiversity and habitat value for different feedstocks. To complement the production of mixed feedstocks, the feasibility of developing conversion technologies that can use multiple feedstocks also needs to be determined.

3. **Identify the environmental impacts of the co-products of biofuel production.** A spectrum of co-products will result from the use of any potential feedstock or agricultural commodity for biofuel development. The environmental consequences of these co-products should be a topic for research as well. For example, rapid growth of the U.S. fuel ethanol industry is increasing the production of dried distillers grains with solubles (DDGS), a nutrient-rich byproduct of corn ethanol production that is used in animal feed. The fermentation process increases the bioavailability of phosphorous and nitrogen in DDGS relative to other sources of animal feed, and this impacts the environment by altering the nutrient content of manure. In some dairy farms and feedlots, DDGS feeds are reversing efforts to decrease phosphorous in manure. Thus research is needed to examine the environmental effects of DDGS and other biofuel co-products and to identify workable methods for returning nutrients in process residues to soils.

4. **Understand the impacts of increased bioenergy production on water supply and improve metrics for assessing water quality.** Water requirements for current biomass production and biorefining are not clearly understood because the data are not publicly available. Large-scale biofuel production could significantly increase industrial water consumption, and for some regions, lack of water could limit construction of production facilities. Irrigation for energy crops is another water supply issue. Input (pesticide, fertilizer) requirements that may end up in the water supply will vary depending on the biomass crop and location. Runoff from crops that require these chemicals and wastewater discharge from biofuel production will call for more extensive research and monitoring to assess impacts on ground and surface water supplies.

Priorities at the Intersections of Social, Economic, and Environmental Science

1. **Develop modeling tools for evaluating a range of future bioenergy scenarios.** Scenario development and modeling at regional and even farm levels are needed to explore the costs and consequences of potential bioenergy futures. Some research questions that these models could address include: what are the regional land-use constraints for scaling up feedstock production; how would farm income be affected by new patterns of agricultural production that will differ by region, timescale, and feedstock; what factors determine which land resources will be first to transition to biomass feedstock production; and what external risks and opportunities result from various methods of bioenergy production?

2. **Establish operational and quantifiable metrics to evaluate the sustainability of different bioenergy options.** Assessing the sustainability of a technology involves the examination of a range of social, economic, and environmental factors; this requires a systems approach. Some of the most important challenges to analyzing the sustainability of biomass and biofuel production are limitations that agricultural analysts have faced for decades—lack of monitoring and assessment data, lack of consistent measurement methodologies, lack of data on the extent and impact of biomass crop production in the field, etc. The impacts of bioenergy options vary depending on location and the type of crop or technology deployed. Establishing a standard set of indicators to evaluate each bioenergy technology on a case-by-case basis, and providing a standard method for detailed life-cycle analyses would enable a more meaningful, comparative assessment of bioenergy technology impacts. Analysis of the full-cost and benefit accounting systems to be used by the six pilot cellulosic biorefineries funded by DOE-EERE could be one approach to improving data, models, and metrics.

3. **Evaluate how changes in social, economic, and environmental policy will impact rural communities.** Conflicting policies designed to serve different goals (e.g., economic incentives to influence human behavior, environmental regulations) can be a challenge to developing strategies that promote biomass and biofuel production in rural communities, a particular mission of USDA CSREES. Analyses are needed to identify reasonable tradeoffs between economic growth and environmental benefits, but this is difficult to do when the environmental impacts of bioenergy production are not well understood. The uncertain timescale for analyzing policy impacts at a community level is another complication. Once a policy is established, the timescale for creating change in the community as a result of the policy, evaluating community reaction and policy impacts, and then recognizing or removing regulatory obstacles is highly variable.

4. **Develop education and outreach programs that prepare the next generation of bioenergy workers and consumers, and build community support for bioenergy development.**
   - **Assessment of current education and outreach capacity.** Most communities have extension facilities, however the staff does not have the training needed to help communities become informed about choices regarding bioenergy options. An inventory

of existing education and outreach capacity will help determine available resources, ways to provide training to staff, and to build upon existing efforts.

- **Formal education at universities**. A systems approach is needed to educating a new generation of professionals that can contribute to a growing bioenergy industry. Creating a national initiative for bioenergy education and reinitiating fellowship programs, such as the USDA Multidisciplinary Graduate Education Training, will recruit top students to participate in bioenergy-related research and help universities build teams of faculty members and educational programs that work across traditional disciplines.
- **Education to facilitate community engagement and decision-making.** Extension services need to move beyond expert-mediated education to activities that support cooperative learning from peers and community forums for information sharing. Any plan to educate communities should present a balanced, realistic view of bioenergy options within the context of other renewable energy and efficiency technologies, and be responsive to community inquiries. Keeping economic benefits within local communities will involve educating biomass producers about business structures for conversion, technology ownership issues (companies versus cooperatives), contractual arrangements, infrastructure development, and consumer culture (e.g., Will consumers pay a premium for cellulosic biofuels?).

5. **Evaluate the impacts of using genetically modified organisms (GMOs) and develop a plan for communicating GMO issues to the public**. GMOs will continue to be a controversial issue, and yet may play a significant role in agricultural and/or industrial Bioenergy development. Community attitudes towards GMOs vary based on cultural values and the context in which these organisms will be used (e.g., using genetically modified microorganisms in a controlled industrial setting for conversion versus field-deployment of GMO plants). Implementing high-yield GMO crops will affect existing agriculture and could threaten some traditional crops; methods for quantifying the economic and environmental impacts of GMO crops are needed. Activist groups with strong views regarding the use of GMOs can influence public opinion, and an effective communication plan should have a consistent message based on scientific evidence that can build public consensus and counter misinformation.

If you have questions regarding this report and/or the Joint USDA-DOE Experts Workshop on Bioenergy, please feel free to contact any of the steering committee members, including: Jill Auburn, 202-720-5384, jauburn@csrees.usda.gov; Daniel Drell, 301-903-4742, daniel.drell@science.doe.gov; Pat Hipple, 202-401-2185, phipple@csrees.usda.gov; John Houghton, 301-903-8288, john.houghton@science.doe.gov; and, Anna Palmisano, 202-401-1761, apalmisano@csrees.usda.gov.