Journal of Extension
www.joe.org

February 2015
Volume 53
Number 1
Article # 1FEA2
Feature

Growing Green Energy: A Review of Extension's Role in the Development of Advanced Biofuels

Abstract

The development of advanced biofuels is expanding the possibilities for purpose-grown energy crops. Growers, producers, and other stakeholders will need a reliable source of information to assist with decision-making regarding renewable fuel supply chains. This review examines Extension's role in the innovation of advanced biofuels by documenting and summarizing Extension work in existing biomass-derived energy programs. This review highlights strategies used by Extension programs that help make renewable energy innovations successful.

Nora M. Haider
Extension Coordinator
Washington State University
Everett, Washington
nora.haider@wsu.edu

Shiba P. Kar
Assistant Professor of Natural Resource Planning and Policy & Sustainable Energy Specialist-UW Extension
College of Natural Resources
University of Wisconsin-Stevens Point
Stevens Point, Wisconsin
shiba.kar@uwsp.edu

Patricia A. Townsend
Regional Extension Specialist and Educator,
Washington State University
Everett, Washington
patricia.townsend@wsu.edu

Kevin W. Zobrist
Regional Extension Specialist
Washington State University
Everett, Washington
kevin.zobrist@wsu.edu

Extension and Advanced Biofuels

As the United States looks to develop renewable energy alternatives to fossil fuels, new biomass-based energy sources are being established. This includes advanced biofuels, derived from a variety of woody and non-woody plant materials as opposed to only starch- and sugar-rich food crops. The goals of developing renewable fuels include reducing dependence on fossil fuels, reducing carbon emissions, and creating opportunities to help revitalize rural America (Kelsey & Franke, 2009; Perlack et al., 2005).

Advanced biofuels are emerging as a strategically important source of renewable transportation fuels (Nigam & Singh, 2011). To support new advanced biofuel industries, new agriculture cropping systems are being established across the United States that can provide a steady supply of feedstock to biorefineries. As a trusted information provider in agriculture, natural resources, and energy-related fields, Extension has an important role to play in successful, biomass-based, renewable energy programs. By sharing knowledge, teaching skills, and uniting stakeholders, Extension can be a central

support in the development of advanced biofuels, which are just beginning to reach commercial scale.

New and expanding interdisciplinary bioenergy programs are incorporating the guidance of Extension personnel. These new programs include seven Coordinated Agriculture Project (CAP) grants funded by the United States Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative (AFRI) ("Sustainable Advanced Biofuels," 2014). These research and development initiatives intend to spur new energy markets, promote innovations, and support the local economies of rural America (National Institute of Food and Agriculture, 2012; United States Department of Agriculture, 2013). Each CAP grant includes a significant Extension component to provide outreach and education to key stakeholders.

This article is a literature review to examine Extension's role in the innovation of advanced biofuels by documenting and summarizing Extension work in existing biomass-derived energy programs. This review highlights strategies used by Extension programs that help make renewable energy innovations successful. Through identifying relevant literature and precedents, Extension educators will be better equipped to build education and outreach programs for renewable energy endeavors, specifically programs that involve purpose-grown energy crops.

Extension's Role in a Budding Industry

As advanced biofuel industries reach commercial-scale production, Extension educators can play a vital role in linking and connecting all aspects of the new industry. Extension educators are qualified to share knowledge and impart skills related to all stages of biofuel production. As reliable information providers and accomplished community organizers, Extension educators are in the best possible position to provide knowledge in budding biofuel industries (Fortson, 2006). Biofuel feedstock growers and suppliers will seek Extension's expertise in the cultivation and management of the biomass resources. Stakeholders and decision-makers can use objective, research-based information from Extension to help determine which biomass resources have the greatest potential for developing a successful renewable fuel industry in their area. Extension agents are also in the position to balance the promise of significant financial returns with realistic market expectations (Fortenbery & Deller, 2008).

Information Providers

A transition away from traditional, petroleum-based transportation fuels will require the adoption of new concepts, practices, and products. Extension's role as an information provider in a renewable fuel industry will be to contribute to the diffusion of these ideas. The newness of biofuel industries poses uncertainties that could make potential feedstock growers reluctant to adopt the new crops. Some of these uncertainties might include the status of a local biomass market, negative experiences with new crops in the past, concerns over the cost of investing in production systems, and a general unfamiliarity with cropping methods (Wen, Ignosh, Parrish, Stowe, & Jones, 2009). If growers reject new biofuel feedstock crops, budding local biofuel industries will not survive. For these reasons, a reliable source of information will be vital as new industries grow.

Insufficient information has been a limiting factor in the development of local woody biomass and

bioenergy markets across the United States (Grebner, Perez-Verdin, Henderson, & Londo, 2009; Wen et al., 2009). In many cases, both growers and government officials failed to recognize the probability of increased income, economic development, and the potential for collaborative efforts among landowners and policy makers. In providing technical assistance and educational outreach, Extension agents can increase growers' familiarity with a multitude of topics. Research has shown that Extension services are among the most valued sources of information for a biofuel feedstock grower (Villamil, Alexander, Silvis, & Gray, 2012).

Extension agents can be important contributors to biofuel industries by providing technical assistance and reliable information, increasing growers' familiarity with new bioenergy crops. For example, growers may be reluctant to adopt a new bioenergy feedstock, such as switchgrass. Research investigating switchgrass grown for bioenergy in Virginia found that the grower's hesitation might be due to an underdeveloped market and a lack of familiarity with switchgrass culture (Wen et al., 2009). Research looking at bioenergy crops in Illinois showed that feedstock producers would be more willing to adopt a bioenergy crop if they understood the advantages of biofuels, such as environmental benefits and rural job creation (Villamil et al., 2012). Both of these studies found that Extension materials and activities would be beneficial to the local bioenergy market.

To minimize risk associated with the feedstock producer's uncertainty, Extension can convey technical information to the grower. For instance, the CenUSA AFRI CAP grant uses informative factsheets and videos to share information on growing switchgrass for biofuels (Mitchell, Volenec, & Porter, 2013). Research shows that events with a high level of interaction among stakeholders, such as conferences, meetings, and field days, are the preferred information delivery format (Villamil et al., 2012). Being mindful of this advice, many of the AFRI CAP grant projects are providing information to stakeholders through interactive events hosted by their Extension partners. For example, the Advanced Hardwood Biofuels Northwest project hosts field days to highlight hybrid poplar production as a biofuel feedstock to key stakeholders in the Pacific Northwest (Kantor, 2013).

Stakeholder Collaborators

A variety of stakeholders will unite in new biofuel industries as new technologies are developed and diffused (Jensen, Halvorsen, & Shonnard, 2011). Some of the most notable parties include growers supplying the feedstock; producers generating the liquid fuel; consumers using the resource; communities impacted by land use changes and biorefinery siting; and government entities creating policies that shape the industry. The relevant parties will need to make use of resources that promote collaboration. Extension educators have traditionally been successful in facilitating and coordinating activities, meeting the wide-ranging needs of diverse stakeholders (Rasmussen, 1989). By using Extension as a resource in the renewable fuels industry, the diffusion of new ideas will be more quickly adopted by individual stakeholders (Rogers, 1995).

At the base of the supply chain, growers are the foundation for the entire industry. It is at this level that Extension interactions are most useful and focused. From this level, grower decisions will determine the advancement of an industry, as the regional, large-scale adoption of energy crops will direct the siting of biorefineries. Educational programs for growers will need to focus on topics such as planting and harvesting, specific environmental benefits such as erosion control and input reduction,

and farm labor and equipment issues (Qualls et al., 2012).

During the early phases of industry development, Extension educators can be a resource for communities seeking information related to the feasibility of renewable energy activities in their area and the potential positive and negative impacts of those activities (Fortenbery & Deller, 2008). Research has found that land-grant universities administrating Extension programing are uniquely equipped to organize and partner with stakeholders to stimulate and facilitate private sector investments in new energy economies (Franklin, Humphrey, Roth, & Jackson, 2010). By organizing public forums, Extension professionals are able to help communities bring together appropriate knowledge and build public support for renewable energy production. Extension can participate in energy opportunities by interfacing with outside developers of energy projects, helping them understand the need for early community engagement; identifying appropriate technologies for the community; and assisting with facility design (Franklin et al., 2010).

Extension leaders are also in the position to establish an effective dialogue with state leaders about energy policy incentives that encourage the development of alternative energy resources. In recognition of the environmental cost associated with biofuel production, policies promoting biofuels need to encourage responsible feedstock production and refining practices (Groom, Gray, & Townsend, 2008). Local policy makers pursuing the pros and cons of localized energy production will benefit from the services Extension programs offer.

Addressing Barriers to Advanced Biofuel Production

In renewable energy economies, different stakeholder groups will have different perceptions and priorities for renewable energy projects (Dwivedi & Alavalapati, 2009). Overcoming real and perceived barriers to biofuel production will be crucial if advanced biofuels are going to be successfully produced at a commercial scale. A proactive Extension staff will address these diverse challenges through outreach and education material that focus on the needs of each stakeholder group. Approaching stakeholders in this manner effectively engages growers, suppliers, conversion industries, consumers, and others in the supply chain. Each of these stakeholders will have different and at times conflicting educational needs and expectations from Extension programs (Villamil et al., 2012). Approaching outreach and education pursuits with an inclusive agenda will constructively address misconceptions and questions from a variety of stakeholders. Involving local stakeholders in decision-making processes through greater planning transparency will likely minimize conflict and opposition (Upreti, 2004).

Barriers to the Innovation of Advanced Biofuels

On the path to advanced biofuel commercialization, developing stages of production will face various obstacles stakeholders will need to address. Feedstock growers will experience unique challenges that they may not be willing to undertake. The siting of biorefineries will likely face some resistance and opposition by local constituents, and environmental and political topics will be debated and contested. Research reveals many barriers present in existing feedstock-dependent bioenergy markets. Feedstock production barriers are often correlated to the feedstock grower's familiarity with biomass crops (Marra, Jensen, Clark, English, & Menard, 2012; Wen et al.,2009). Biorefinery developments are

subject to air quality and water availability concerns (Selfa, Kulcsar, Bain, Goe, & Middendorf, 2010). Economic barriers are consistently listed as the top hurdle for commercial scale biofuel production (Kelsey & Franke, 2009; Volk et al., 2006). The challenge for Extension personnel is proactively anticipating and acknowledging these kinds of obstacles (Plate, Monroe, & Oxarart, 2010).

Many studies explore potential barriers that may impede renewable energy markets. For example, survey research conducted in Iowa and Kansas took a community case study approach to exploring the public's perception of existing ethanol plants to gauge the impacts of the biofuel industry on the local community (Selfa et al., 2010). The intent of the survey was to investigate social dimensions impacted by biofuel production to contribute to more informed policy regarding bioenergy. Survey respondents evaluated the significance of a biorefinery in relation to the local economy, social impacts, and environmental harms. The researchers found that about 80% of the surveyed residents felt that the ethanol plants contributed jobs to the community, although most felt that the jobs were not well paid. Many in the surveyed communities also felt that water resources and air quality were points of concern. Communities that had experienced water restrictions in the past were more likely to express concerns over the ethanol plant's water uses (Selfa et al., 2010). Extension educators can incorporate their knowledge about barriers into bioenergy education programs within communities impacted by bioenergy developments.

Applying Strategies to Overcome Barriers

The successful adoption of renewable energy production methods in the necessary bioenergy supply chain will rely on Extension personnel who are involved and informed. This will be critical in identifying barriers and opportunities influencing stakeholders. Although Extension programs relating to advanced biofuels are limited because of the newness of the industry, strategies for other Extension programs and methods are applicable. In the growing bioeconomy, Extension can get a jump-start on addressing misconceptions by applying past lessons learned to new bioenergy Extension pursuits. Extension educators should also remember that education and outreach strategies might not be appropriate in all situations. It would be irresponsible of Extension educators to promote an industry or crop that is not in the best interests of their constituents.

Extension research from the University of Florida offers a well-documented glimpse into bioenergy outreach and education programs. Several studies analyze the various strategies used in the Wood-to-Energy Outreach Program that serves the southern United States. The Wood-to-Energy Outreach Program provides information, tools, and resources in an effort to increase community understanding and discussions regarding the possibility of using wood for energy (Interface South, 2012). As the program developed, researchers assessed public acceptance and support for biomass energy programs throughout the region (Monroe & Oxarant, 2010). Mailed surveys revealed that the public had a low level of knowledge about woody biomass, fossil fuels, electricity production, and carbon neutrality. This led the researchers to determine that outreach material should be simple yet accurate (Oxarart & Monroe, 2012). Community forums were conducted with the understanding that public input can be a critically important consideration for community-based issues. Community forums are a useful way for people who care about an issue to learn more so that they are able to contribute to the solution (Monroe, Oxarart, McDonell, & Plate, 2009). The Wood-to-Energy program provides a

resource new Extension programs can build from to support advanced biofuels production around the country and the world.

In recognition of the economic barriers to biofuel production, Extension educators at the University of Wisconsin-Madison developed computer software that allows users to estimate community impacts based on expected benefits resulting from the siting of a local biorefining plant. This program allows users to evaluate community impacts based on plant employment opportunities, plant sales, and the income earned by plant employees (Fortenbery & Deller, 2008). Community decision-making software allows Extension educators the opportunity to provide an informed analysis of the community impacts resulting from biofuel production through an objective economic impact tool. When Extension assumes a broader role in the local community through the modeling of economic impacts, local residents and officials can make better-informed decisions. Extension educators can use the results of the analysis to build educational programs that address challenges that specific communities face (Shields & Deller, 2003).

Advanced biofuel developments and crop adaption will not be suitable for all farmers and all communities. Extension maintains creditability by developing programs that are non-biased and research based, which stakeholders can use to assist with decision-making (Clark et al., 2012). An important role for Extension will be to balance the positive and negative impacts of biofuel production in specific regions and prompt stakeholders to consider critical questions to assess their support for the development. Table 1 proposes some questions growers and communities may want to consider before participating in biofuel developments.

Table 1.

Key Questions to Consider for Successful Biofuel Developments

For farmers	For Community members
• Are there markets for biofuel feedstock crops in my area? • Will the bioenergy crop's profit margin justify the adoption of the new crop? • Is there a long-term guarantee of market opportunities? • Is my land suitable for the efficient production of bioenergy crops? • What are the long-term plans for my land and where do bioenergy crops fit?	• What are potential environmental impacts resulting from biofuel production? • Will there be an increase in traffic in my community? • How will this bioenergy development affect my quality of life? • Can biofuel industry developments increase incomes in my community in the long run?

Recommendations

As advanced biofuel production develops, Extension educators will play a key role in informing and

assisting growers in the adoption and production of biofuel feedstocks. By establishing a critical mass of feedstock growers, the foundation of a robust bioeconomy will be built. Further, Extension's interactions with local community members will be useful for engaging, informing, and encouraging public participation in the production of advanced biofuels. Extension's role in a budding renewable fuel industry will be to design educational opportunities that provide specific and useful information allowing stakeholders to make informed decision regarding renewable energy in their area.

Based on the literature reviewed, specific recommendations emerge for renewable energy Extension programming. First, Extension's support for growers producing biofuel feedstock is essential. As the foundation of the supply chain, growers' decisions will dictate the success of the industry. Second, all relevant stakeholders should be involved in decision-making processes from the earliest practical point. This will ensure that working relationships are built; misconceptions are addressed and minimized; and potential barriers to biofuel production are acknowledged. Last, Extension educators need to acknowledge and respond to social, economic, and environmental concerns. These issues are the most salient for stakeholders involved in renewable energy projects. By promptly recognizing these factors, Extension can proactively respond to budding renewable fuel industry needs and community demands.

References

Clark, S., Daly, R., Jordan, E., Lee, J., Mathew, A., & Ebner, P. (2012). Extension education symposium: The future of biosecurity and antimicrobial use in livestock production in the United States and the role of extension. *Journal of Animal Science*, 90(8), 2861-2872. http://dx.doi.org/10.2527/jas.2011-4739

Dwivedi, P., & Alavalapati, J. R. (2009). Stakeholders' perceptions on forest biomass-based bioenergy development in the southern US. *Energy Policy*, 37(5), 1999-2007.

Fortenbery, T. R., & Deller, S. (2008). Understanding community impacts: A tool for evaluating economic impacts from local bio-fuel production. *Journal of Extension* [On-line], 46(6) Article 6FEA2. Available at: http://www.joe.org/joe/2008december/a2.php

Fortson, L. (2006). 25 by '25: Extension's role in rural energy development. *Journal of Extension* [On-line], 44(5) Article 5TOT3. Available at: http://www.joe.org/joe/2006october/tt3.php

Franklin, N., Humphrey, J., Roth, G. W., & Jackson, D. G. (2010). A time of opportunity: Energy, extension, and economic development. *Journal of Higher Education Outreach and Engagement*, 14(3), 13-46. Retreived from: http://openjournals.libs.uga.edu/index.php/jheoe

Grebner, D. L., Perez-Verdin, G., Henderson, J., & Londo, A. (2009). Bioenergy from woody biomass, potential for economic development, and the need for Extension. *Journal of Extension* [On-line], 47(6) Article 6FEA7. Available at: http://www.joe.org/joe/2009december/a7.php

Groom, M. J., Gray, E. M., & Townsend, P. A. (2008). Biofuels and biodiversity: Principles for creating better policies for biofuel production. *Conservation Biology*, 22(3), 602-609. Retreived from: http://onlinelibrary.wiley.com/journal/10.1111/%28ISSN%291523-1739

Interface South. (2012). *Wood to energy*. Retreived from: http://www.interfacesouth.org/products/wood-to-energy

Jensen, J. R., Halvorsen, K. E., & Shonnard, D. R. (2011). Ethanol from lignocellulosics, U.S. federal energy and agricultural policy, and the diffusion of innovation. *Biomass & Bioenergy,* 35(4), 1440-1453.

Kantor, S. (2013). *WSU Extension showcases poplar demonstration sites*. Retreived December 29, 2013 from Advanced Hardwood Biofuels Northwest. Retreived from: http://hardwoodbiofuels.org/wsu-extension-showcases-poplar-demonstration-sites/

Kelsey, K., & Franke, T. (2009). The producers' stake in the bioeconomy: A survey of Oklahoma producers' knowledge and willingness to grow dedicated biofuel crops. *Journal of Extension* [On-line], 47(1) Article 1RIB5. Available at: http://www.joe.org/joe/2009february/rb5.php

Marra, A. E., Jensen, K. L., Clark, C. D., English, B. C., & Menard, R. J. (2012). Information sources and farmers' attitudes toward switchgrass production as a biofuel feedstock. *Journal of Extension* [On-line], 50(5) Article 5RIB6. Available at: http://www.joe.org/joe/2012october/rb6.php

Mitchell, R., Volenec, J., Porter, P. (2013) *Establishing and managing perennial grass energy crop demonstration plots*. Retreived from: https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=67

Monroe, M. C., & Oxarant, A. (2010). Woody biomass outreach in the southern United States: A case study. *Biomass & Bioenergy*, 35(4), 1465-1473. http://dx.doi.org/10.1016/j.biombioe.2010.08.064

Monroe, M. C., Oxarart, A., McDonell, L., & Plate, R. (2009). Using community forums to enhance public engagement in environmental issues. *Journal of Education for Sustainable Development*, 3(2), 171-182.

National Institute of Food and Agriculture. (2012) *NIFA-AFRI Regional Sustainable Bioenergy Systems Coordinated Agriculture Projects (A6101).* Retreived from: http://www.nifa.usda.gov/nea/plants/pdfs/2012_sustainable%20bio_coord_%20factsheet.pdf

Nigam, P. S., & Singh, A. (2011). Production of liquid biofuels from renewable resources. *Progress in Energy and Combustion Science*, 37(1), 52-68.

Oxarart, A., & Monroe, M. (2012). Using interesting text to communicate complex natural resource issues. *Journal of Extension* [On-line], 50(1) Article 1FEA8. Available at: http://www.joe.org/joe/2012february/a8.php

Qualls, D. J., Jensen, K., Clark, C., English B., Larson J., & Yen, S. (2012). Analysis of factors affecting willingness to produce switchgrass in the southeastern United States. *Biomass and Bioenergy,* 39, 159-167.

Perlack, R. D., Wright, L. L., Turhollow, A. F., Graham, R. L., Stokes, B. J., & Erbach, D. C. (2005). *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply.* USDA, Oak Ridge, Tennessee. Retrieved from:

http://web.ornl.gov/~webworks/cppr/y2001/rpt/123021.pdf

Plate, R., Monroe, M., & Oxarart, A. (2010). Public perceptions of using woody biomass as a renewable energy source. *Journal of Extension* [On-line], 48(3) Article 3FEA7. Available at: http://www.joe.org/joe/2010june/a7.php

Rasmussen, W. D. (1989). *Taking the university to the people: Seventy-five years of Cooperative Extension.* Ames, Iowa: Iowa State University Press.

Rogers, E. M. (1995). *Diffusion of innovations, 4th Edition.* New York: The Free Press.

Selfa, T., Kulcsar, L., Bain, C., Goe, R., & Middendorf, G. (2010). Biofuels bonanza? Exploring community perceptions of the promise and perils of biofuel production. *Biomass & Bioenergy*, 35(4), 1379-1389.

Shields, M., & Deller, S. C. (2003). Using economic impact models as an educational tool in community economic developement programming: Lessons from Pennsylvania and Wisconsin. *Journal of Extension* [On-line], 41(3) Article 3FEA4. Available at: http://www.joe.org/joe/2003june/a4.php

Sustainable advanced biofuels across the United States. (2014). Retrieved from: http://hardwoodbiofuels.org/wp-content/uploads/2014/05/AFRI-CAP-overviewFinal.pdf

United States Department of Agriculture. (2013). *USDA invests in research to convert beetle-killed trees into renewable energy*. Retreived from: http://www.csrees.usda.gov/newsroom/news/2013news/11061_bioenergy_cap.html

Upreti, B. R. (2004). Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales. *Energy Policy*, 32(6), 785-800. http://dx.doi.org/10.1016/S0301-4215(02)00342-7

Villamil, M., Alexander, M., Silvis, A. H., & Gray, M. E. (2012). Producer perceptions and information needs regarding their adoption of bioenergy crops. *Renewable and Sustainable Energy Reviews*, 16, 16(6), 3604-3612.

Volk, T., Abrahamson, L., Nowak, C., Smart, L., Tharakan, P., & White, E. (2006). The development of short-rotation willow in the northeastern United States for bioenergy and bioproducts, agroforestry and phytoremediation. *Biomass & Bioenergy*, 30(8-9), 715-727.

Wen, Z., Ignosh, J., Parrish, D., Stowe, J., & Jones, B. (2009, October). Identifying farmers' interest in gorwing switchgrass for bioenergy in Southern Virginia. *Journal of Extension* [On-line], 47(5) Article 5RIB7 . Available at: http://www.joe.org/joe/2009october/rb7.php

---