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30 Ag Products to Energy
The world faces some daunting challenges, one of which is energy. How can energy be provided to meet the demands of a population growing in number and in expectation?

Much of the world’s energy comes from coal, oil, and natural gas. This fossil energy has some great attributes. It is cheap, energy-dense, plentiful, and has a well-developed infrastructure for extraction, refining, distribution, and use. It has fueled much of the development and operation of the world’s economy, as we know it.

Unfortunately, there is a downside: There is collateral damage, associated with large-scale use of and dependence upon fossil energy, which has security, environmental, and economic implications. Though large quantities remain, fossil supplies are finite. As for oil, some suggest that half of the world’s supply has been consumed and that demand will soon exceed the capacity to produce. As demands increase, and because supply disruption consequences are great, maintaining adequate energy supplies becomes an issue of national security for countries competing for dwindling supplies. There is concern about environmental implications of the amount of carbon, largely as carbon dioxide, being released into the atmosphere as hydrocarbons are burned. The major transfer of wealth from fossil-consuming regions of the world to fossil-producing regions has huge economic consequences, not to mention social and political implications.

Developing and implementing renewable and sustainable means of providing adequate energy to meet the needs of the world can eliminate reliance on fossil energy. Though not a trivial task, it is an achievable goal. Capturing the sun’s energy (the closest thing we have to a truly renewable energy source) and converting it into usable energy forms can reach the goal. The challenge is to make it happen, and that is where agricultural and biological engineers come in. Our profession will play a major role in development of efficient and effective sustainable energy systems – systems that make use of bioenergy from agriculture and forestry, as well as other forms of renewable energy, to effectively, sustainably, and economically meet the world’s energy needs.

Donald C. Erbach, USDA-ARS (retired)
don.erbach@mac.com

ASABE SECTION AND COMMUNITY EVENTS

2008
March 25
Quad City Awards Meeting.
Contact Eric Windeknecht,
WindeknechtEricD@JohnDeere.com.

April 15
Quad City Section Tour.
Contact Eric Windeknecht,
WindeknechtEricD@JohnDeere.com.

June 12-14
Florida Annual Section Meeting, Trade
Show, and Continuing Education Program.
Duck Key, Florida, USA. Contact Lisa Collins,
3gators@gmail.com. www.fl-asabe.org.

2009
Jan. 5-9
Frutic Chile 2009: Eighth International
Symposium of Information and Technology
for the Sustainable Production of Fruit
and Vegetables, Nuts, Wines, and Olives.
Concepcion, Chile. www.frutic09.org.

ASABE ENDORSED EVENTS

2008
July 13-16
50th Annual Conference of the Canadian
Society for Bioengineering, North Vancouver,
British Columbia. www.bioeng.ca/Events/

2009
The push for the United States to produce more biofuels was reinforced by the recent amendment to the 2005 Renewable Fuels Standard, setting a new target of 136 billion L (36 billion gal) by 2022. Cellulosic biofuels will play a major role in reaching this goal.

For nearly a decade, the multidisciplinary biofuels research team led by Oklahoma State University (OSU) has been investigating a gasification-fermentation process in which low-cost, under-utilized biomass, such as perennial grasses and crop residues, is converted to ethanol and other value-added products. A holistic approach is being employed, addressing the more critical issues along the continuum from biomass production to liquid fuel generation. In this bioconversion process, the total biomass including lignin is utilized, which can result in high energy conversion efficiency.

The process begins with biomass gasification where, under a controlled oxygen supply, cellulose, hemicellulose, and lignin are converted to a producer gas, primarily CO, CO$_2$, and H$_2$. The producer gas then flows through a cleaning and cooling system and is subsequently directed to a bioreactor. The gas is bubbled through the bioreactor where microorganisms (acetogens) convert the gas into ethanol and other value-added products. The mixture is further processed to separate and recover these products.

The biofuels team is among a select few research groups having successfully produced ethanol from biomass-generated producer gas. Besides linking the gasifier to the bioreactor, the team has identified several novel solvent-producing anaerobic microbial catalysts, one being *Clostridium carboxidivorans* P7, which was isolated from the sediment of an agricultural settling lagoon. To date, P7 is the most researched of the suite of microbial catalysts the team has in their collection. It was the first reported microbe in which biomass-generated syngas, rather than commercially mixed gases, was used to produce ethanol.

P7 has been subjected to producer gas generated from switch grass using a pilot-scale fluidized bed air gasifier operating at 770 – 800°C. Gas composition is typically 14 to 19 percent CO, 15 to 18 percent CO$_2$, 3 to 5 percent H$_2$, 4 to 5 percent CH$_4$, and 50 to 60 percent N$_2$, with remaining constituents mostly C$_2$ compounds and low levels of NO$_x$. About 90 to 94 percent of carbon in switch grass is converted to carbonaceous components in the producer gas with the balance in the forms of ash and tars.

Gaseous impurities, such as methane, acetylene, ethylene, ethane, nitric oxide, and tars, can affect the performance of microbial catalysts. Thus, improved gas quality through better gasifier design and operation and enhanced gas cleanup are high-priority research areas.

One of the most critical factors in bringing bioproducts to the marketplace is, of course, the cost of production. The goal of the research team is to produce ethanol at a cost less than $1.25 U.S. per approximately 4 L (1 gal) based on a conversion efficiency of 285 L (75 gal) per dry ton of biomass. It is envisioned that this work could result in the establishment of numerous centralized, small- to medium-scale ethanol production facilities that can be located throughout cultured biomass production and waste biomass generation areas. Each facility could have a significant positive impact on the rural economy. For example, a 189-million-L (50-million-gal) per year biomass-to-ethanol conversion facility would provide more than $40 million U.S. to a local economy, while the facility would provide full-time employment for more than 30 individuals.

The research efforts by the OSU biofuels team were recently highlighted through the announcement of a partnership between Coskata, Inc. (www.coskata.com) and General Motors in bringing next-generation ethanol to the marketplace. Coskata is the company that has licensed the microbial catalysts being researched at OSU.

Sponsors of this research include the Oklahoma Agricultural Experiment Station; USDA-CSREES; Coskata, Inc.; the South Central Sun Grant Initiative; and the Oklahoma Bioenergy Center.

ASABE Fellow Raymond L. Huhnke is professor, Oklahoma State University Biosystems and Agricultural Engineering Department, Stillwater, Okla., USA; raymond.huhnke@okstate.edu.
Rethinking ThermoChemical Conversion of Biomass into Biofuel

Yuanhui Zhang

All fossil fuels found in nature – petroleum, natural gas, and coal, based on biogenic hypothesis – are formed through processes of thermochemical conversion (TCC) from biomass buried beneath the ground and subjected to millions of years of high temperature and pressure. In particular, existing theories attribute that petroleum is from diatoms and deceased creatures, and coal is from deposited plants.

TCC is a chemical reforming process of biomass in a heated and usually pressurized, oxygen-deprived enclosure, where long-chain organic compounds (solid biomass) break into short-chain hydro-carbons such as syngas or oil. TCC is a broad term that includes gasification (Fisher-Tropsch process), liquefaction (hydrothermal process), and pyrolysis (anaerobic burning). Gasification of biomass produces a mixture of hydrogen and carbon monoxide, commonly called syngas. The syngas is then reformed into liquid oil with the presence of a catalyst. Pyrolysis is a heating process of dried biomass to directly produce syngas and oil.

Both gasification and pyrolysis require dried biomass as feedstock, and the processes occur in an environment higher than 600°C. The hydrothermal process involves direct liquefaction of biomass, with the presence of water and perhaps some catalysts, to directly convert biomass into liquid oil, with a reacting temperature of less than 400°C.

Historically speaking

The development of TCC technologies has always been linked to the energy shortage. Gasification of coal was first invented in 1923 by Franz Fischer and Hans Tropsch (consequently the name for the process) at the Kaiser Wilhelm Institute in the oil-poor, but coal-rich, Germany. By the end of World War II, Germany had produced more than 6 million metric tons (6.6 million tons) per year of synthetic oil from coal gasification. Then the 1970s oil crisis arrived. The Bureau of Mines in the United States investigated TCC of coal and wood to produce liquid fuel, and several pilot plants were developed. However, the economics of the technology was not sustained, largely due to the continuing low price of petroleum. The Fischer-Tropsch-type plants are in operation today in only a few countries including Germany, South Africa, and the United States.

$$ today

Today, petroleum prices have reached a historic high. It is time to rethink the TCC technology for biomass conversion – not only for the sustainability of energy, but also for the protection of the environment.

From biomass to biofuel

TCC may have two pathways from biomass to biofuel: (1) direct conversion of biomass or (2) pretreatment of biomass and then fermentation. The biomass with little lignocellulosic fraction – such as waste streams from animal, human, and food processing – can be directly converted into biofuel thermochemically. Researchers at the University of Illinois have successfully developed TCC processes that converted

This laboratory-scale continuous thermochemical conversion reactor could process 40 L (10.5 gal) of fresh swine manure and produce 4 L (1 gal) of crude oil per day.

Continued on page 27
With increasing concerns over dwindling reserves and unstable supplies of petroleum coupled with climate change caused by the burning of fossil fuels, the search is on for cleaner energy. Biomass is a solar energy resource with the potential to be a significant contributor to the United States’ energy portfolio with a low carbon footprint. Several types of biomass are currently used as feedstocks in energy conversion processes to produce liquid fuels, power, and heat, including wood, agricultural, and forest product residues and municipal solid and industrial waste.

Energy goals set by President George W. Bush (Twenty in Ten), the U.S. Department of Energy (30x30), the private sector and interest groups (25x25), and Congress (which recently enacted Energy Independence and Security Act of 2007) to develop biobased fuels will require an unprecedented engagement of American agriculture in domestic energy production.

Many states are also supporting biofuels. For example, California recently enacted a Low-Carbon Fuel Standard to reduce the carbon intensity of transportation fuels sold in that state by 10 percent by 2020. Many of the low carbon fuels expected to be commercially available in large quantities in California within the 2020 time horizon are anticipated to be biofuels.

Research and development the focus

The primary biofuels produced at a commercial scale today in the United States are ethanol, which exploits the starch resources in corn and other grains, and transesterified biodiesel from oilseed crops, such as soybeans and animal fats. Ethanol production and use is approaching 3 percent of our total national fuel consumption today and is expected to reach about 7 percent by the end of this decade. However, to expand anticipated biofuels production in the future and as new biomass energy conversion processes are perfected to produce “advanced” biofuels, research is focusing on improving the characteristics of existing biomass feedstocks as well as exploring the potential for new energy crops and new biobased fuels/products.

For example, research is being conducted on sugar and starch crops to make them more efficient in existing conversion processes, e.g., new strains of sugarcane that produce more sugar and enable these tropical crops to be grown in more temperate climates and oilseed crops that increase the yield of oil and have enhanced fuel quality attributes.

### USDA Candidate Plants for Biofuel Garden and Exhibit (Power Plants)*

<table>
<thead>
<tr>
<th>U.S. National Arboretum</th>
<th>Barley</th>
<th>Sugar beet</th>
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<tbody>
<tr>
<td>Corn</td>
<td>Sorghum</td>
<td>Sunflower</td>
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<tr>
<td>Barley</td>
<td>Sugar beet</td>
<td>Soybean</td>
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<tr>
<td>Sunflower</td>
<td>Canola</td>
<td>Castor bean</td>
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<tr>
<td>Sugar beet</td>
<td>Camelina</td>
<td>Peanut</td>
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<td>Canola</td>
<td>Lesquerella</td>
<td>Mustard</td>
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<tr>
<td>Castor bean</td>
<td>Sugar cane</td>
<td>Switch grass</td>
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<tr>
<td>Peanut</td>
<td>Hybrid popular</td>
<td>Miscanthus</td>
</tr>
<tr>
<td>Mustard</td>
<td>Alfalfa</td>
<td>Jatropha</td>
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<tr>
<td>Switch grass</td>
<td>Cuphea</td>
<td>Babassou Palm</td>
</tr>
<tr>
<td>Jatropha</td>
<td>African Oil Palm</td>
<td>Algae</td>
</tr>
</tbody>
</table>

*Scheduled for June 2008

Most of the federal research and development effort is focused on developing the “next generation” of biofuels that will allow lignocellulosic crops, both herbaceous and woody plants, and crop and forestry residues to be converted into biofuels. Both herbaceous and woody crops are more widely available biofuel feedstocks than sugar and starch crops. One of their greatest advantages is that they are short-rotation, perennial crops; they regrow after each harvest, allowing multiple harvests without having to be replanted. Switch grass, which is indigenous to U.S. prairies where it is grown to reduce soil erosion and to create wildlife habitats, is being studied extensively for its potential as an energy crop. One recent study, conducted by the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) shows that switch grass yields more than five times the energy needed to grow, harvest, and transport the grass and convert it to ethanol.
Alfalfa is also another potential energy crop that, unlike corn and other grasses, fixes its own nitrogen and thus requires less fertilizer.

Crop and forestry residues may also be collected as by-products, such as corn stover or rice or wheat straw, or they may be collected at processing facilities such as lumen mills, cotton gins, or vegetable processors. Residues, especially corn stover, are expected to be the first feedstocks for cellulosic biofuels to be used. However, excessive residue removal can increase soil erosion and reduce soil productivity. ARS recently conducted a long-term study in eastern Nebraska to evaluate the impact of stover harvested for bioenergy on soil productivity. It concluded that more residues than previously thought must be retained on the field to avoid adverse impacts on soil productivity. Major breakthroughs in cellulosic conversion and commercialization are expected within the next five to ten years that will help to bring additional sources of cellulose into sustainable, environmentally sound use.

Traditional oilseed crops, including soybeans, canola, mustard seeds, and sunflower seeds, are grown throughout the United States for biodiesel production and new crops, such as camelina and jatropha, show potential. Some varieties of algae are known to produce large amounts of fatty acids and have been proposed as biofuel feedstocks.

The future’s best of the best

The best energy crops may be those that are multipurpose and allow farmers to respond to market changes by combining food, feed, fiber, and biofuel product streams. Many advances have already been made with conventional plant breeding using molecular genetics and plant physiology to significantly improve crops. These technologies can also lead to significant improvements in bioenergy feedstocks.

In the future, engineered plants may be the solution to low-cost, abundant feedstocks. By tweaking plant genes, scientists can encourage production of more biomass or change a plant’s cell wall composition so that it can be readily converted into biofuels or industrial products such as lubricants, inks, fabrics, or glue. ARS has 20 gene banks across the country that can be used to design, develop, and produce better energy crops.

Considerations vis-à-vis sustainability will be an important consideration in the emerging, high-volume biofuels industry. A federal government National Biofuels Action Plan points out that there is currently “limited understanding of potential impacts of large-scale energy feedstock production on land uses, water, carbon sequestration, and ecosystems (particularly excess fertilizers, pesticides, and sediment in surface waters) ...”

Because of the wide variation in biomass feedstocks and their impacts by geographic location, research is being conducted on many of these issues on a regional basis. Land grant and other universities, as well as ARS, are evaluating various crops for suitability and sustainability based on eco-region, genetic variation, and production economics. Some land grant universities have joined together in five geographical locations throughout the country to address regional biomass feedstock capabilities in terms of sustainable production for energy purposes. Many of these crops will be on public display at the USDA Energy Garden exhibit being developed for mid-2008, (see USDA Candidate Plants on previous page) to inform the public on a range of plants that are grown in the United States that are, or have potential to be, used as renewable energy sources.

The biomass resources in this country have the potential to make a significant impact on energy use not only as fuel but as bioproducts. For this potential to come to fruition, it will require the research, education, and extension resources of USDA and its university partners to help develop the technology, sustainability, and profitability that will be needed to build a clean and prosperous energy future.

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For further information:

Biofuel Feedstocks
The risk of future invasions
Jacob N. Barney and Joseph M. DiTomaso

To reduce greenhouse gas emissions, expand domestic energy production, and maintain economic growth, public and private investments are being used to pursue dedicated feedstock crops for biofuel production. A variety of plant species, including grasses, herbs, and trees, are being considered for use as dedicated biofuel crops across much of the country. The leading candidates for lignocellulose-based energy, however, are perennial grasses, most of which are not native to much of the region where production is proposed. From an agronomic perspective, their life history characteristics, rapid growth rates, and tonnage of biomass produced by these non-native grasses make them ideal feedstock crops.

Unfortunately, several of the candidate biofuel feedstock species being considered for commercial production in the United States are invasive pests (e.g., non-native species causing economic or environmental damage) in other regions where they have been introduced. Their invasiveness is largely attributed to their life history characteristics and rapid growth rates. The combination of being non-native and possessing weedy characteristics, along with their potential scale of cultivation, presents a significant risk that biofuel crops could escape cultivation and potentially damage surrounding ecosystems. This risk may be exacerbated when biofuel crops are cultivated on lands surrounded by sensitive forest, prairie, desert, and riparian areas, as well as rangelands and agricultural commodities.

Breeding and, most recently, genetic engineering techniques have greatly benefited agricultural crops, particularly with respect to enhanced productivity and yield. Most modified crops (e.g., corn, rice, wheat, soybean, cotton, tomato, and alfalfa) have not become pests due to their inability to survive without cultivation and their requirements for irrigation, nutrients, and pesticides. Unlike most major crops, biofuel feedstocks are being selected from taxa that produce highly competitive stands that thrive with minimal human intervention. These species present a high risk of becoming invasive when they possess few resident natural enemies, exhibit rapid establishment and growth rates, tolerate broad environmental variation, and produce large quantities of easily dispersed seeds or vegetative reproductive structures.

Numerous examples exist of non-native species being introduced for agricultural purposes — especially as livestock forage and for horticultural use — that escape the confines of agricultural production and cause unforeseen ecological damage (e.g., johnsongrass: *Sorghum halepense*; kudzu: *Pueraria montana* var. *lobata*). Dedicated energy crops, which are similar to these escaped species, are also being modified to have drought or salt tolerance and enhanced nutrient-use efficiency, affording cultivation with limited human intervention on marginal lands that possess few resources. This enhancement in environmental tolerance likely will increase the risk of escape from cultivation and invasion into surrounding environments. Similarly, enhancement of aboveground biomass production via biotechnology could allow such cultivars to be more competitive with native vegetation or other cultivated crops.

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Convergence of Agriculture and Producing cellulosic biomass for biofuels

Steven L. Fales, J. Richard Hess, and W. W. Wilhelm

Current biofuel production in the United States relies primarily on corn grain conversion to ethanol, and in 2007 approximately 26 billion L (7 billion gal) of ethanol were produced. It is estimated that an additional 30 to 34 billion L (8 to 9 billion gal) are possible from corn, assuming additional acres planted to corn, projected yield increases, and improvements in processing technology. To meet the Department of Energy’s strategic goal of 227 billion L (60 billion gal) of ethanol by the year 2030 will require massive amounts of biomass in addition to corn grain. To achieve this goal, significant and immediate national investments are needed, along with changes in policy, to address the agronomic, economic, and environmental challenges limiting the sustainable biomass feedstock production and use. Biomass resource development, supply, and conversion systems, crop genetics, and agronomic management practices must be improved to meet the challenge of an agricultural industry that produces food, feed, fiber, and fuel.

Near-term obstacles for the emerging cellulosic ethanol industry are the inefficiencies associated with immature feedstock production practices, marketing and logistics systems, and conversion processes. In other words, all aspects of the industry are new and inherently inefficient. If biofuels technology is not mature in all aspects from supply to end-product distribution, it will be only partially able to accommodate the higher feedstock prices that are caused by supply/demand effects.

A pressing need is for the development of a comprehensive, coordinated national plan advancing sustainable bioenergy production. Existing research-and-development efforts are spread across federal agencies, state governments, universities, and private industry. Developing a comprehensive, coordinated, widely accepted, and publicized set of goals and completing an overall national strategic plan with realistic goals and assigned responsibilities may be the greatest short-term action needed. Actions are needed in the following focus areas to ensure production and delivery of feedstock in the volumes necessary to achieve established goals.

Resource assessment

The biofuel industry will need reliable and realistic appraisals of current and future feedstock supply in addition to evaluation of the supply stability. Such assessments must occur at two levels. First, state- or region-specific inventories of current and projected feedstock production capacity are needed. Second, national crop yield databases must be expanded to include biomass yield data for all major and prospective cellulosic feedstock crops. Data should be reported on an agro-ecoregion/soil resource basis. Reliable biomass inventories and projections will greatly aid business planning and policy development.
Agronomic systems

Practices and incentives are needed to encourage sustainable feedstock production as a co-component of existing food, feed, and fiber production systems to provide biomass for early generation cellulosic ethanol processors. Both traditional and renovated versions of current production systems will be necessary to grow the feedstock required; however, the ideal approach may involve cultivated perennial crops that decrease tillage frequency, increase biomass partitioned below ground, and exhibit beneficial ecosystem services such as improved wildlife habitat and enhanced air and water quality.

Crop development

Although progress can be made by adapting current crop species and varieties to sustainable feedstock production systems, gains required to produce the amounts of biomass, and in turn ethanol, targeted over the next 10 to 20 years will require cultivars specifically designed for this purpose. There is a need to expand investment in breeding and genetic improvement of dedicated energy crops. This must include a commitment to and an investment in building scientific capacity in plant genetics, physiology, biochemistry, genomics, breeding, and production systems for these new or evolving crops.

Feedstock supply logistics

Feedstock supply system logistics encompasses operations necessary to move biomass from the land to the biorefinery. Collectively, these harvesting, transporting, and preprocessing activities represent one of the largest challenges to this success of the industry. Improvements in feedstock supply system equipment capacities, equipment efficiencies, and biomass quality are needed and will lead to enhanced conversion and, in turn, create revenue to be shared among the feedstock producer, supplier, and refiner.

Education and extension

A biobased energy economy will require a workforce with skills and knowledge to operate equipment and processing plants designed to convert biomass to fuel. Scientists and engineers trained in plant biology, physiology, breeding, genomics, agronomy, soil science, and ecology will be needed to sustainably expand the feedstock supply. Public support for research in these fields must be expanded. As new crops and agronomic systems are developed, extension and outreach programs will be needed to educate farmers.

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Borlaug Dialogue Engages in Global Biotech Discussion

International experts offer bio-views

Frank Swoboda

One of America’s foremost conferences on international food and agriculture, the Norman E. Borlaug International Symposium, attracted more than 700 participants from around the world to Des Moines, Iowa last year to discuss “Biofoods and Biofuels: Global Challenges of Emerging Technologies.”

The symposium, known as the “Borlaug Dialogue,” is held each October in conjunction with the awarding of the $250,000 World Food Prize. The 2007 event gathered diverse policymakers, industry officials and executives, and leading researchers and experts to discuss how to balance growing biofuels demand with the need for a nutritious food supply.

Several global agribusiness leaders stressed biotechnology’s role in meeting increased pressures on agriculture.

“If you fast forward 20 years, there will be another two billion citizens, and food demand will double,” said Monsanto CEO Hugh Grant. Grant praised partnerships among governments, agribusiness, academia, and non-governmental organizations (NGOs) as a way to effectively and responsibly face challenges related to bioenergy and food security.

Charles Holliday, CEO of DuPont, drew on his company’s experience in phasing out chlorofluorocarbons (CFCs) as an example of private sector leadership in sustainability. He called on his colleagues in business and government to similarly move toward confronting climate change.

Jeffrey Cox, Syngenta’s president of global corn and soybeans, emphasized enhanced crops for biofuels production – corn and soybeans, as well as crops like sugar beets – in developing countries. “The dynamic shift in emerging economies...coupled with the acceleration of the developing biofuels industry is going to completely change the way we look at agriculture,” Cox said.

Chris Policinski, CEO of Land O’Lakes, urged the agricultural and scientific sectors to cultivate wider understanding and informed public discussion of issues like biotechnology.

U.S. Assistant Secretary of State Daniel Sullivan said greater acceptance of biotechnology, in addition to flexible global trade schemes, will be crucial in guaranteeing a strong future for bioenergy. “There will obviously be short-term challenges as the global economy adjusts to the biofuels revolution,” he said.

Speakers avoided framing their views in terms of “food versus fuel.” Acting U.S. Secretary of Agriculture Chuck Conner contended that “the anxieties of this issue have been running way, way ahead of any market reality,” and listed several Agricultural Research Service programs supporting biofuels production.

Several speakers from countries in Africa, Asia, Europe, and Latin America held that, despite initial promise, work remains to ensure that bioenergy is ecologically sustainable, commercially viable, and socially beneficial.

South African Minister of Agriculture Lulama Xingwana discussed bioenergy in the context of climate change, regional food insecurity, and post-apartheid land reform. South Africa, she said, aims “to empower emerging marginal farmers and prepare them for this new biofuels industry” as a means of bolstering development.

Ibrahim Rehman of The Energy and Resources Institute in India and Chen Zhangliang of China Agricultural Uni-
sity also emphasized bioenergy’s potential for pro-poor rural growth, cleaner energy, and advanced crop development – jatropha for biodiesel in India’s case, and in China, sweet sorghum for ethanol.

Others raised cautionary voices. The UN World Food Program’s John Powell questioned how the world’s poorest farmers, many of whom are landless or lack access to modern technologies and markets, will profit from biofuels. He also named biofuels as one factor – along with rising food prices and currency devaluation – increasing the cost of providing food aid.

David Molden of the International Water Management Institute in Sri Lanka stated that global water resources, already strained, cannot support bioenergy in addition to food production.

Birgitte Ahring of the Technical University of Denmark criticized corn as an inefficient energy feedstock and championed biomass as an option for producing renewable liquid fuel.

Suzanne Hunt, formerly of the Worldwatch Institute, contrasted successful business and technical models in Latin America with shortcomings of the North American auto industry in terms of creating a sustainable bioenergy industry.

In the face of such challenges, several speakers added that bioenergy also presents an opportunity for enhanced international cooperation to achieve agricultural, commercial, and ecological benefits. Among them was Norman Borlaug, 1970 Nobel Peace Prize Laureate and “Father of the Green Revolution.”

In 1986, Dr. Borlaug founded the World Food Prize, which since 1990 has been headquartered in Iowa. Several heads of state have called the annual $250,000 award “the Nobel Prize for Food and Agriculture.”

Full “Borlaug Dialogue” transcripts and more information are available at www.worldfoodprize.org.

Frank Swoboda is director of planning, The World Food Prize Foundation, fswoboda@worldfoodprize.org.
With **25x'25** as Established Goal, the **REAL WORK** Must Begin

Read Smith

The National **25x'25** Alliance – with recent accomplishments that mark the initiative’s maturity and set the stage for expanding the vision further – is now preparing to make the **25x'25** goal a reality. The coalition’s capstone achievement to date is the signature into law by President George W. Bush in December of energy legislation that endorsed the **25x'25** Vision. The measure expresses the sense of the Congress that “it is the goal of the United States that no later than January 1, 2025, the agricultural, forest, and working land of the United States, should provide from renewable resources not less than 25 percent of the total energy consumed in the United States and continue to produce safe, abundant, and affordable food, feed, and fiber.”

In a little more than the three years, the **25x'25** Alliance has gone from a small group of farm leaders to more than 600 agriculture, forestry, environmental, energy, business, labor, and government partners. The **25x'25 Initiative** has contributed to a changed political environment in Washington, D.C., and around the country and is working with other renewable energy champions to do the work necessary to achieve **25x'25**. With a clear goal now written into the federal statutes, work is underway to establish the **25x'25 Initiative** as the “source authority, for timely and factual information about renewable energy solutions from agriculture and forestry and to secure the adoption of necessary enabling public policies, particularly through advancing the 35 recommendations of the **25x'25 Action Plan: Charting America’s Energy Future**, presented to Congressional leaders last year.

Using the **25x'25 Action Plan** as its framework, the coalition of partners is pushing for policies at national, state, and local levels that can 1) sustain the nation’s resource base and protect the environment; 2) boost the use of woody biomass; 3) meet biofuel and electricity infrastructure challenges; and 4) clarify how agriculture and forestry can reduce and capture greenhouse gas emissions – all while improving soil, water, and air quality and wildlife habitat, lowering the costs of energy, and improving economic and national security.

Complementing those policy initiatives is a sustainability work group created last year and now engaged in defining a sustainable **25x'25** energy future. Also underway is an effort to explore the role the agriculture and forestry sectors can play in a reduced carbon economy. The **25x'25 Coalition** is also taking an active role in promoting the research and education needs that will enable its partners, Congress, and state legislatures to more effectively support and encourage the U.S. Department of Agriculture, the U.S. Department of Energy, academic institutions, state agencies, and private sector administrators, scientists, and educators in meeting the **25x'25** goal.

**THE 25X’25 ALLIANCE HAS GROWN FROM A SMALL GROUP OF FARM LEADERS TO MORE THAN 600 AGRICULTURE, FORESTRY, ENVIRONMENTAL, ENERGY, BUSINESS, LABOR, AND GOVERNMENT PARTNERS.**

The coalition will facilitate the engagement of partners, including the American Society of Agricultural and Biological Engineers, on critical challenges and opportunities in creating a **25x’25** renewable energy future. The coalition stands ready to equip and mobilize ASABE and other national partners and state alliances to proactively bring **25x’25** to life.


Read Smith is a co-chair of the National **25x'25** Alliance, and with his wife and son, he manages family farming interests, raising wheat, barley, and minor crops and managing a cow/calf operation in Whitman County, Washington, USA; read_s@stjohnncable.com.
Sustainable production of bioenergy is in the spotlight. It is estimated that one billion tons of biomass are needed to replace 30 percent of current annual petroleum consumption in the United States alone. Meeting the global challenges to reduce dependence on fossil fuels requires the expertise of ASABE’s agricultural and biological engineers. Tons of biomass must be collected, stored, transported, and processed in a timely and economical fashion into competitively priced fuels and consumer products. Ag and bio engineers are uniquely qualified to develop the most efficient and effective methods of handling biomass feedstocks.

Working through ASABE, members have fostered the development of bioenergy by selecting energy and energy management as a top strategic focus; developing environmentally sustainable technology for biomass feedstock production, delivery, and the very processes for converting biomass to energy; encouraging revisions to existing standards and engineering practices that relate to bioenergy and identifying needed new standards; and encouraging development and delivery of technical programs and peer-reviewed publications on bioenergy along with providing instructional materials to enhance bioenergy education.

All bio-subtopics of the bioenergy field have produced growing study and research within academia – from undergraduate to post-doc focus. Colleges and universities are addressing the need for interdisciplinary approaches to supply the burgeoning market for renewable energy, and ASABE members within the ivory towers are at the fore.

The following short summaries provide an overview of current and planned bioenergy-related programs and endeavors across North American campuses today.

Auburn University Center for Bioenergy and Bioproducts Emphasizes the Interdisciplinary

Auburn University has a wide range of active programs in bioenergy and bioproducts being conducted by multiple departments and centers. Activities are coordinated by the Center for Bioenergy and Bioproducts, which is part of the Natural Resources Management & Development Institute. Other units with major emphases in bioenergy and bioproducts include the colleges of agriculture, engineering, and forestry and wildlife sciences.

The signature elements of Auburn’s bioenergy programs include:

- biomass feedstock supply chain logistics;
- biomass fractionation;
- biomass gasification and subsequent production of liquid transportation fuels and electrical power;
- biochemical conversion with emphasis on pretreatment of cellulosic feedstocks;
- biofuel testing; and
- extension and outreach programs helping farmers, businesses, and municipalities in the production of energy and value-added products.

The Center for Bioenergy and Bioproducts emphasizes systems approaches in all research and extension efforts and is constructing a central laboratory facility that will bring together faculty and students from across the campus.

The first phase of the facility includes laboratories dedicated to biomass feedstock processing, biomass fractionation, and biomass gasification and gas-to-liquids conversion. The gasification laboratory will house a recirculating, oxygen-blown, fluidized bed gasifier followed by a hot gas cleanup system and multiple gas-to-liquids reactors. Later phases of the facility will include laboratories for biomass pretreatment and biochemical conversion, transesterification, and fuel and engine testing.

Auburn University displays the mobile biomass gasification, combined heat and power generation unit at Alabama Energy Day in January 2008.
Another unique capability of the Center is a mobile gasification and power generation unit that allows field deployment and demonstration of thermochemical conversion processes. This mobile unit is allowing researchers to study the on-site processing and gasification of low-density biomass feedstocks, and it provides a unique educational platform for teaching gasification principles to university students and extension clientele.

The department of biosystems engineering also is very active in Auburn’s energy and bioproducts programs. Departmental research focuses on systems to produce, harvest, and transport agricultural and forest biomass; processing systems for size reduction and densification of biomass; biomass gasification for power and heat production; and biodiesel production systems. Extension programs target biomass supply chain logistics; biodiesel production for farms and municipalities; and energy management and conservation for agricultural production enterprises that include aquaculture, horticulture, and poultry sectors. Special emphasis is placed on meeting the engineering needs of the poultry industry through major extension programs in poultry technology. Additional extension programs are working with municipalities as they establish recycling programs for both residential and commercial producers of used cooking oils followed by biodiesel production. These extension programs aim to develop energy and value-added product solutions to local or community problems. For more information, contact ASABE member Steven Taylor, taylostd@auburn.edu.

Clemson University Biodiesel Facility Studies Waste Food Oils

Maj or advantages of renewable fuels include the creation of local economy, reduced dependency on foreign oil, cleaner emissions, sustainability, and reduction in transportation costs. To stimulate research interest at Clemson, a biodiesel facility was constructed in collaboration between biosystems engineering and environmental health and safety. The facility is powered by solar panels and a biodiesel generator to integrate renewable technologies as proof of concept for running the facility off-grid. Research has focused on use of waste food oils collected by biodiesel vehicle, cottonseed oil, and algal oils reacted with ethanol. Graduate students in biosystems engineering and undergraduates enrolled in creative inquiry operate the facility.

Clemson University collaborates with Kent SeaTech of California to develop low-cost microalgae production systems. Joint funding supports studies using microalgae culture for biodiesel production (National Science Foundation), wastewater treatment (U.S. Department of Agriculture, Environmental Protection Agency), and greenhouse gas sequestration (U.S. Department of Energy).

Thirty field and research-scale algal production systems have been installed and operated in South Carolina and California. Innovative, open-pond micro algal production technologies, based on Clemson’s patented “Controlled Eutrophication Process,” have been developed and evaluated. Recent work focuses on developing lower-cost techniques of recovering algal-generated lipid for biodiesel production from large-scale marine algal culture. One technique utilizes high density *Artemia* (brine shrimp) culture for uptake and conversion of algal biomass in to easy-to-extract animal lipid. Advantages include eliminating the need for expensive algal species control techniques in mass algal culture operations; the cost of direct harvesting, concentration, and drying of microalgae biomass; and the cost of solvent boiling used for conventional algal-oil extraction.

Because more than 90 percent of hydrogen produced globally derives from fossil fuel, non-fossil fuel sources of hydrogen are needed. Biological hydrogen production by fermentative pathways can convert up to 33 percent of the stored energy in organic waste streams to hydrogen gas to be utilized in polymer exchange membrane fuel cells. Clemson research with hyperthermophilic bacterium Thermotoga neapolitana has shown that a variety of organic carbon and nitrogen compounds and raw agricultural wastes can be effectively fermented to hydrogen gas with high efficiency. Acetate produced as by-product of fermentation can be converted to electrical energy in a microbial fuel cell, a specialized biological reactor that operates on the same principles as hydrogen fuel cells. In microbial fuel cells, electrons processed during normal cellular respiration are “intercepted” by an anode and diverted to power electrical devices. Linking the technologies represents a potential bioenergy production scenario. Ongoing research will determine the energy recovery and waste treatment efficiency of using spent hydrogen fermentation broth as substrate for microbial fuel cell operation. Contact ASABE member William Allen, whallen@exchange.clemson.edu, for more information.

Kansas State University Boosts Biofuel as Priority

Bioenergy and bio-based products can substantially improve environmental quality, rural economics, and national security. The department of biological and agricultural engineering (BAE) at Kansas State University (KSU) has a unique infrastructure to develop enabling technologies and provide solutions to ease bioenergy-related issues. In the BAE bioenergy research program, biofuel has been prioritized as one of the three research areas of excellence with ASABE members Donghai Wang, Wengiao Yuan, and Naiqian Zhang as the three key faculty members in this field.
Wang is actively conducting research on the utilization of grain sorghum and sorghum biomass for more efficient production of ethanol and bio-based products. His research concentrates on analysis of the relationship among “genetic-structure-function-composition-conversion” and understanding key factors impacting the bioprocessing of selected products. Current research projects include sorghum as a viable renewable resource for biofuels; development of a comprehensive understanding and utilization of sorghum stover and forage sorghum for ethanol production; and utilization of sweet sorghum for ethanol production. Wang is a team leader of the bioenergy technology research group of the KSU Center for Sustainable Energy recently funded through the KSU Targeted Excellence Program.

Yuan joined the BAE Department in 2006 with strong interests in bioenergy. His current research projects include biomass pyrolysis for bio-oil production with focus on converting agricultural residues such as sorghum stover, corn cobs, animal manure, etc., into crude-like oils through novel catalyzed hydrothermal pyrolysis; biomass gasification for syngas production with focus on value-added utilization of agricultural and forest residues as well as system optimization and product utilization; and algal biofuel production with focus on algal species selection, cultivation, harvesting, oil extraction, biofuel conversion, and residual biomass utilization.

Zhang is developing an inexpensive, multifunctional, real-time sensor to measure biodiesel/diesel and ethanol/gasoline blend ratios. When biodiesel/diesel blends are used in diesel engines, the injection timing should be adjusted based on the blend ratio to achieve the optimum working condition that yields both high fuel efficiency and low emissions. Similar adjustment is also needed for gasoline engines fueled with ethanol/gasoline blends. Thus, a sensor that is capable of accurately measuring the blend ratios is very important. The developed sensor will also be tested in measuring impurities in biofuel, such as water in biodiesel. For further news, contact ASABE member Donghai Wang, dwang@ksu.edu.
McGill University Endorses Initiatives on Bioenergy and Bioproducts

There are several multi-disciplinary teams of researchers within McGill University working on different aspects of bioenergy and bioproduct creation. McGill’s Network for Innovation in Biofuels and Bioproducts was recently formed to encourage and promote more activity in these areas. This is the only research network in Canada specifically focused on biomass production, its transformation to biofuels and bioproducts, as well as the assessment of biomass utilization and socioeconomic and environmental aspects.

The department of bioresource engineering provides active leadership in the engineering components of biofuel and bioproduct research activities at McGill. In this regard, the department recently hired three new academic staff members with expertise in process optimization, biofuels, bioproducts, and ecosystem engineering to add to the existing staff. Current projects in the department include the optimization of extraction processes for improved yield of oil from oilseeds, conversion of oils to biodiesel and recovery of glycerol byproduct, and biogas production.

ASABE members Michael Ngadi, Valerie Orsat, and G.S.V. Raghavan are investigating innovative, gentler, and more effective extraction methods that should reduce dependence on environmentally hazardous chemicals. There is also an ongoing project on the production of biodiesel from waste oils and animal by-products.

Although alkaline-catalyzed biodiesel production from triglycerides is well established, that process has several drawbacks, such as difficulties in the recovery of glycerol, the need to remove salt residue, disposal of reaction residues, and the energy-intensive nature of the process. These drawbacks are being addressed through the investigation of new enzymes for biological transesterification so as to increase the yield of biodiesel, reduce cost, and minimize the formation of undesirable co-products. Conversion of glycerol to methanol and ethanol is also being studied. Work is in progress on in-storage anaerobic digestion of manure and source separation of organic waste for biofuels.

There is currently a plan to construct a new pilot plant on campus specifically for the study of biofuel and bioproduct processing. Several professors from the department are also actively involved in international projects in countries such as India, with the objective to build capacity and to collaborate in several areas including gasification, biodiesel production, engine testing of biofuels, bioreactor designs, and pilot plant design.

For more information contact ASABE member Michael Ngadi, michael.ngadi@mcgill.ca.

This high pressure autoclave is used for hydrothermal liquefaction (HTL) experiments at LSU. The HTL process involves converting wet biomass slurries (saw dust, animal wastes, etc.) to bio-oils by exposing the biomass to elevated temperatures and pressures in presence of a process gas for residence times of up to 15 to 30 minutes. The unit produces acetone-soluble, crude-like oil with a high heating value of approximately 37 MJ/kg. More than 75 fundamental experiments have been successfully completed. Future research will focus on net-energy balance computations, oil characterization, and screening for high-value products.

post-harvest processing of alternative; non-traditional feedstocks, such as Chinese tallow tree seeds; innovative extraction methods using microwave technology; and continuous microwave transesterification.

Hydrothermal liquefaction

BAE researchers are conducting fundamental research on thermochemical liquefaction process (TCL), which involves converting biomass to bio-oils by exposing the wet biomass slurries (wood chips/animal wastes) to elevated temperatures (>300°C/572°F and higher) in presence of a pressurized process gas for residence times of up to 20 to 30 minutes.

Fuel Testing

The W.A. Callegari Environmental Center, which is under the BAE’s administrative authority, has a fully equipped and staffed analytical laboratory for conducting biodiesel and fuel analysis. This capability complements the engine dynamometer in the department.

For more details, contact ASABE member Chandra Theegala, theegala@lsu.edu.
Fueling Bioenergy Endeavors

Michigan State University Center for Bio-based Renewable Energy Continues to Expand in Faculty and Program

The Michigan State University (MSU) Center for Bio-based Renewable Energy is a multidisciplinary center established in 2006 to promote renewable, bio-based energy through teaching, research, and outreach. The department of biosystems and agricultural engineering collaborates with the department of chemical engineering and materials science and the department of forestry in this venture.

The Center is funded by the MSU Quality Fund and is in a start-up phase, hiring faculty to complement existing faculty active in this area. The program is expected to be fully functional in 2009.

The Center plans to achieve three-pronged objectives through:

Education
Courses will be developed in the technical, economic, and environmental aspects of energy from agricultural and forestry biomass. They will form the core of an undergraduate option in renewable energy as well as an integrated curriculum option for several engineering and agriculture and natural resources majors at the undergraduate and graduate levels. Collaborative opportunities for students and faculty will include student internships in research laboratories and study abroad. The Center is expected to produce graduates with various skill levels related to the implementation of long-term sustainable energy resource and use practice.

Research
A bioenergy research laboratory will conduct biomass production research in the following areas: genetically modified energy crops; thermal, chemical and biological processes to convert agricultural and forestry biomass and waste materials; and reforming processes to convert biofuels and biogas into high-purity, fuel-grade hydrogen.

Outreach
The Center will publish materials to promote energy conservation and bioenergy utilization. A Web site will provide a medium to communicate MSU’s progress to the public. Collaborations with community colleges is intended to give these academic institutions the necessary expertise to train workers for new jobs related to transitioning from the current energy base to the future energy resource-use situation. In addition, international collaborations will provide opportunity to exchange successful practices from abroad.

Oklahoma State University Researches Conversion Pathways

Faculties in biosystems and agricultural engineering at Oklahoma State University (OSU) have been at the forefront of interdisciplinary bioenergy research and education programs in Oklahoma. OSU research projects involve the study of several different conversion pathways. External support comes from the U.S. Department of Agriculture, the U.S. Department of Transportation through the Sun Grant Initiative (www.sungrant.okstate.edu), and the Oklahoma Bioenergy Center.

GRASSohol: converting biomass to ethanol using gasification-fermentation

In this hybrid thermochemical process, biomass is combusted in a gasifier under conditions of controlled oxygen supply where the plant components (cellulose, hemicellulose, and lignin) are converted to a synthesis gas (primarily CO, CO$_2$, and H$_2$). The syngas is cleaned and cooled prior to being injected into a bioreactor where it is microbially catalyzed to a mixture of ethanol, inert gases, water, and other potentially useful products such as acetic acid. The OSU team is taking a holistic approach, i.e., from the production of biomass to the generation of ethanol and other products, addressing the more critical issues in moving this bioconversion process to commercialization. Participating institutions are the University of Oklahoma, Brigham Young University, and Mississippi State University. Team lead is ASABE member Ray Huhnke, who can be contacted at raymond.huhnke@okstate.edu.

Enhancing enzymatic conversion of cellulosic materials by simultaneous saccharification and fermentation (SSF) with Kluyveromyces marxianus (IMB) strains

*Kluyveromyces marxianus* IMB strains are being used in SSF processes to produce ethanol from cellulosic materials at 45°C. This temperature allows for greater cellulose activity than SSF at 37°C with tradition ethanolgens. At 45°C, up to...
80 percent of the cellulose in switch grass can be converted to ethanol. Currently, researchers are investigating the best conditions for use of the IMB4 strain for maximum ethanol production with various cellulosic feedstocks. The University of Ulster is collaborating on this project. Project lead is ASABE member Mark Wilkins, mark.wilkins@okstate.edu.

Production of ethanol from sweet sorghum

The process being investigated involves on-farm, in-field production of ethanol. Due to seasonality of sorghum production, it may be more cost effective to convert juice to ethanol on-farm rather than transport the entire crop to a central processing plant. The proposed process involves harvesting and pressing stalks in the field using a new field harvester/press currently being developed by a private firm. The collected juice would then be fermented in the field using large “bladders” for storage. Distillation of the ethanol mixture could be achieved at the farm level or a central location. Project lead is ASABE member Dani Bellmer, danielle.bellmer@okstate.edu.

Purdue University Pursues Bioenergy Initiatives

Faculty members in the agricultural and biological engineering (ABE) department at Purdue University are leading a number of research, education, and outreach activities regarding bioenergy.

In addition to an on-campus course on bioenergy (Process Engineering of Renewable Resources) taught by ASABE member Nathan Mosier, a non-credit professional development course (ABE/GEAPS 590: Fundamentals of Ethanol Production) has been developed and is taught by ASABE member Klein Ileleji and Mosier. This course is an intensive five-week module utilizing distance-learning technologies that is offered in collaboration with the Grain Elevator and Processing Society (GEAPS). Additional modules are in the development stage, which will provide continuing education for professionals who work in or with the fuel ethanol industry.

The ABE department is leading a Purdue College of Agriculture Rapid Response Team focused on addressing applied research questions regarding the rapid rise of Dried Distillers Grains with Solubles (DDGS) production that parallels the rapid rise in ethanol production.

Specific research emphases include:
- biomass harvest methods to maximize digestibility;
- co-ensiling DDGS and forages for improved storage;
- DDGS physical properties and materials handling, including method development for industry grading of DDGS;
- co-firing switch grass and coal for electrical power generation;
- pretreatment of cellulosic biomass, including DDGS, for ethanol production;
- interdisciplin ary research projects with colleagues in agronomy, botany, forestry, and biochemistry for improving biomass crop genetics in maize, poplar, and switch grass for improved bioprocessing to liquid fuels; and
- continued development of genetically modified yeast for industrial cellulose ethanol production.

ABE faculty members are leaders in a Purdue College of Agriculture effort to provide answers for livestock and grain producers and the public at large on bioenergy issues. For more information visit the Purdue Bioenergy Web site at www.ces.purdue.edu/bioenergy/.

Biofuels Engineering and Science Initiatives at Texas A&M University

The biological and agricultural engineering department (BAEN) at Texas A&M University has a bioenergy program focused on understanding biomass harvesting and production logistics, characterization, conversion processes, value-added processing of by-products, and related environmental issues. Collaborators in these projects include the University of Arkansas, Louisiana State University, Texas Tech University, the United States Department of Energy, General Atomics, the Cotton Foundation, Houston Advanced Research Center (HARC), the National Resource Conservation Service (NRCS), and SUNGRANT.

The logistics project is concentrated on evaluating the energy and cost advantages of modules (as used in cotton harvesting) for packaging and transporting biomass energy crops. In addition, methods are being developed for harvesting high-tonnage sorghum and animal manure to deliver a
Production of biofuels using traditional food crops, such as corn to produce ethanol or soybeans to produce biodiesel, has the unintended and undesirable consequence of increasing food prices worldwide. Indeed, the food price index of the Food and Agriculture Organization of the United Nations, based on export prices for 60 internationally traded foodstuffs, rose 37 percent in 2007. What is more, the global demand for biofuels has precipitated the large-scale clearing of rainforests in parts of southeast Asia, drawing environmentalists, energy companies, consumers, indigenous peoples, and governments into rancorous disputes. Paradoxically, current biofuel-production schemes have inadvertently become part of the very environmental problem that it is attempting to ameliorate.

To link biofuel production to long-term sustainability, the department of agricultural and biosystems engineering at the University of Arizona focuses on the development of nonfood biofuel crops that are especially well suited for the semi-arid conditions of southern Arizona with its abundance of sunlight and desert lands and limited water supply. The top nonfood biofuel crop candidates include sweet sorghum and green algae.

“Sweet sorghum, as opposed to grain or milo sorghum, loves heat and loves drought, and so is a perfect ethanol crop for semi-arid Arizona,” says ASABE member Donald Slack, the department head. He adds that sweet sorghum is salt-tolerant and can be irrigated with wastewater effluent. The department is an active participant in a study that identifies sweet sorghum varieties with high sugar content that are amenable to production in reclaimed water. The department recently received a research grant from the Bureau of Reclamation for Water Conservation in Biofuel Development. Led by faculty member Robert Freitas, the study is evaluating the use of biochar (a by-product of biofuel biomass pyrolysis) as a soil amendment to increase the water-holding capacity of typical of central Arizona soils and to reduce the required amount of water to grow sweet sorghum.

“Green algae by far is arguably the best biofuel feedstock because it grows fast, is water-efficient when grown in vessels (photobioreactors), can be grown using reclaimed water and on marginal desert lands, and best of all will not pressure food prices to go up,” says faculty and ASABE member Joel Cuello, who is designing scalable consistent, high-quality bioenergy feedstock to processing plants. In the biomass characterization program, different manure streams from dairies and feed yards in Central Texas and the Texas Panhandle are being characterized and evaluated as possible feedstocks for coal co-firing and on-site conversion systems. In the biodiesel-related research, optical sensing techniques for measuring oil content in microalgae are in development stages. This includes optimizing parameters for the growth and oil-producing properties of microalgae such as atmospheric composition, water quality factors, and light characteristics for the production of biodiesel.

Please visit the Web site at http://betalab.tamu.edu or contact ASABE member Sergio Capareda, scapareda@tamu.edu, for more details.

The University of Arizona Links Biofuel Production to Sustainability
The University of California (UC), Davis has a long history of research in biomass and bioenergy systems. Building from investigations beginning in the 1960s on productive uses for agricultural residues disposed in environmentally degrading ways and accelerating after the first oil shock of 1973, research activity has grown so that the campus now operates major multi-disciplinary programs in bioenergy, biofuels, and sustainable biomass production systems.

Research programs encompass biochemical and thermochemical conversion, bio-based products, plant modification, production and harvesting systems, markets, logistics and economics, environmental and social impacts, life cycle assessment, sustainability standards, systems analysis and optimization, and policy.

The UC Davis Bioenergy Research Group is a collaborative group that coordinates activity across campus with emphasis on identifying the molecular, biological, chemical, physical, engineering, and ecological requirements and solutions for maximizing the utilization of plant and microbial resources for sustainably producing bioenergy and other products. The group forms the core research basis for the UC Davis Bioenergy Center under the newly established UC Davis Energy Institute. Advanced education in bioenergy is offered through a number of departments and programs, including biological and agricultural engineering, chemical engineering and materials science, civil and environmental engineering, plant sciences, biotechnology, plant pathology, genetics, environmental science and policy, economics, microbiology, molecular and cellular biology, transportation technology and policy, and others.

Graduate training in bioenergy is a critical component of the proposed Energy Graduate Group on campus. UC Davis also administers the California Biomass Collaborative for the state. It is a joint government, industry, academic, and environmental organization, which has been influential in helping to shape state policy on bioenergy, including the California Bioenergy Action Plan, the low carbon fuel standard, and other energy and climate change legislation. Working with support from the California Energy Commission, other state and federal agencies, and utility and industry partners, the Collaborative has, since 2003, been directly involved with assessment and planning for the sustainable development of California's biomass resources, including agricultural, forestry, and urban residues as well as purpose-grown crops.

The California Institute of Food and Agricultural Research, the Sustainable Transportation Energy Pathways program within the Institute of Transportation Studies, the Genome Center, the Agricultural Sustainability Institute, the John Muir Institute of the Environment, the Energy Efficiency Center, and UC Cooperative Extension also operate bioenergy-related research and teaching programs. Bioenergy research on campus is supported through a broad spectrum of government, foundation, and industry contracts and grants, including the recent joint research agreement with Chevron Technology Ventures, a five-year, $25-million program with focus on novel processes for producing transportation biofuels. UC Davis is also a partner campus in the Joint Bioenergy Institute, one of three major bioenergy research institutes funded by the U.S. Department of Energy.

For more information, contact ASABE member Bryan M. Jenkins, UC Davis Energy Institute Director, bmjenkins@ucdavis.edu and visit http://bioenergy.ucdavis.edu and http://biomass.ucdavis.edu.

**Bioenergy Research Coordinated across Campus at University of California, Davis**

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For more information, contact ASABE member Bryan M. Jenkins, UC Davis Energy Institute Director, bmjenkins@ucdavis.edu and visit http://bioenergy.ucdavis.edu and http://biomass.ucdavis.edu.
University of Florida Scales Up ... and More

The agricultural and biological engineering department (ABE) at the University of Florida is actively engaged in biofuel-related activities. Research focuses on synthesis, design, modeling, control, and optimization of processes for biological and thermochemical conversion of biomass to ethanol, butanol, biodiesel, synthesis gas, hydrogen, and methane. The projects involve taking bench-scale research findings to the prototype and industrial scale by identifying scale-up issues, process control and operational strategies, and optimal and economical process configurations. Extension programs focus on incorporating hands-on workshops, in-service training, and demonstration facilities for biofuel production.

ABE is collaborating with microbiology and cell science to scale-up a biorefinery, using bacteria genetically engineered, to convert both hexose and pentose sugars to ethanol, butanol, and other high-value chemicals. Pilot scale facilities include size reduction and comminuting equipment, a hydrolyzer, solid-liquid separation devices, pilot-scale and bench-scale fermentors, and analytical equipment to test a variety of feedstocks for biofuel potential and to optimize the conversion process. Research is underway to recover other value-added products during the refining process and to maximize water reuse.

ABE is operating a 379-L (100-gal) batch biodiesel processor to convert waste grease from campus dining areas to biodiesel for use in the campus’s vehicles and machinery. Research includes intensification of the transesterification reactions and recovery and value addition to byproducts.

Biogasification research includes biochemical studies on various feedstocks, development of sensors for monitoring anaerobic digesters, isolation of novel wood degrading anaerobic microorganisms, and several process designs to handle a variety of biomass feedstocks. One of these designs, the sequential anaerobic batch composting (SEBAC) process, has been commercialized.

A prototype biogasification system was constructed for NASA as part of Advanced Life Support system for application in planetary bases during long-term space missions. Currently, a demonstration plant is being constructed in Minnesota for Xcel Energy and American Crystal Sugar Company to biogasify the byproducts and waste streams from sugar beet processing.

In collaboration with a materials science and engineering professor, a project is underway to use biogas from anaerobic digesters as fuel for solid oxide fuel cells or as feedstock for production of synthesis gas and/or hydrogen. Biogas conversion is carried out in a ceramic membrane reactor in which the hydrogen is separated in situ. The other exit stream is rich in carbon monoxide and can be combined with the pure hydrogen stream in appropriate ratios to produce defined mixtures of syngas.

For more information, contact Robin Snyder, rsnyder@ufl.edu, and visit www.abe.ufl.edu.

The University of Georgia: From Peanut Hulls to Fuel, Trees to Technology

The University of Georgia (UGA) biorefining and carbon cycling program includes a group of faculty and staff from the disciplines of engineering, crop and soil science, forestry, and life sciences. They focus on research, outreach, and education in aspects of biomass production and conversion to value-added products including fuels, energy, and specialty chemicals. Interdisciplinary focus areas include:

- research to understand biomass, conversion, and products;
- development and testing thermochemical and biological technologies for a bio-based industry;
- technology transfer within Georgia and around the world, working with industries, government agencies, and the community at large; and
- educational programming that provides unique, pertinent, and comprehensive experiences developing the workforce of the 21st century bio-based economy.

UGA hosts a pilot thermochemical biorefinery that converts peanut hulls to hydrogen (or other fuels)
and produces a carbon char co-product. The integrated biorefinery model is a closed-loop process, analogous to the petroleum refinery, where biomass is converted into multiple products while a portion of the carbon is cycled into long-term soil carbon sequestration as BioChar.

At UGA’s biological sciences, forestry, and agricultural schools, tree and crop production and harvesting technology is being developed. These include cellular-level studies to understand fundamental cell wall biochemistry and to design better biomass and its uses (BioEnergy Science Center, www.bioenergycenter.org). There are also larger-scale mechanical system developments applied to harvesting and preprocessing of biomass for improved overall production of biofuels and products. Preprocessing technologies being advanced include pelletization, torrefaction, solvent extraction, hydrolysis, etc.

The program also has an algae biomass subgroup focusing on growing various species of algae on industrial and agricultural wastewaters. Focus includes developing algae production, harvesting, and conversion technologies at the bench and pilot scales. Conversion technologies being studied include pyrolysis, liquefaction, catalytic conversion, fermentation, and transesterification.

The biorefinery and carbon cycling program represents a truly cross-disciplinary effort within the University of Georgia. Significant opportunities in graduate education are available in a number of disciplines. For further information see www.biorefinery.uga.edu.

Bioenergy for Sustainability and Competitiveness Advances at the University of Illinois

The bioenergy initiatives in the department of agricultural and biological engineering, University of Illinois, include various endeavors and varied activities.

- **Corn dry-grind process and co-product improvement for ethanol production**
  
  Corn fractionation technologies to recover highervalued coproducts during ethanol production are in the development stages. Development and testing of process methodologies, such as use of granular starch hydrolyzing and proteolytic enzymes, transgenic corn with endogenous alpha amylases, and dynamic control of simultaneous saccharification and fermentation are constants. These processes may decrease energy and water requirements and lower capital costs. For more information, contact ASABE member Vijay Singh, vsingh@uiuc.edu.

- **Thermochemical conversion of waste and biomass to crude oil**
  
  Swine manure, an abundant waste biomass, has been converted into crude oil in minutes using a novel thermochemical conversion (TCC) technology. This technology mimics Mother Nature’s millions-of-years process of turning deceased living matter beneath the ground into petroleum. A research group is investigating other feedstock, including crop residue, food processing waste, and algae to produce biofuel and protect the environment using TCC. Contact ASABE member Yuanhui Zhang, yzhang1@uiuc.edu.

- **Biodiesel fuel properties, engine performance and emission**
  
  Collaborating with mechanical science and engineering in the formation of a U.S. Department of Energy-funded Graduate Automotive Technology Education Center of Excellence, the department has focused on advanced automotive biofuel combustion engines. This collaboration includes an investigation into biodiesel-fueled engines under low temperature combustion strategies. Contact ASABE member Alan C. Hansen, achansen@uiuc.edu.

Agricultural engineering students Jacob Mdluli (from the University of KwaZulu-Natal, South Africa), Jon McCrady, and Joshua Vonk (from the University of Illinois) prepare a sample of biodiesel. (Photo courtesy of Alan C. Hansen)
Fueling Bioenergy Endeavors

• **Engineering solutions for biomass feedstock production**
  This research program within the BP-funded Energy Biosciences Institute at the University of California, Berkeley; University of Illinois at Urbana-Champaign; and Lawrence Berkeley National Laboratory includes five interrelated tasks: pre-harvest crop production, harvesting, transportation, storage, and systems informatics and analysis. Systematic approaches are taken to evaluate existing technologies, characterize task features, identify information needs and researchable questions, develop prototypes and computer models, conduct experiments and computer simulations, analyze experimental data and simulation output, and deliver results in the forms of operational machinery design/prototype and decision support information/tools. Contact ASABE member K. C. Ting, kcting@uiuc.edu.

• **Bioenergy system informatics and analysis**
  This research activity aims at providing the decision-making infrastructure for a smooth transition from petroleum to bio-based economies. Tasks include engineering and economic model integration for testing viability of new conversion and co-product recovery technology and project management database development for the purpose of gauging research impact in the agricultural sector. Contact ASABE member Luis Rodriguez, lfr@uiuc.edu.

University of Minnesota Research Projects Simmer on Bio-based Burner

At the University of Minnesota Department of Bioproducts and Biosystems Engineering, the core mission is to search for ways to enhance the sustainable use of renewable resources and the environment. The department collaborates on several interdisciplinary projects in diverse areas ranging from bioenergy and bio-based products to environment, ecology, building systems, and food. Many projects related to biofuels and bioenergy are funded through the Initiative on Renewable Energy and the Environment supported by funding from the state of Minnesota.

A number of research projects involve converting biomass to create biofuels and bioenergy. For example, one project will grow algae in wastewaters from treatment plants and effluents and the CO₂ from exhaust gases from industrial plants and convert them into biodiesel. Another project explores whether crop residue in various forms can be used to heat and power corn-ethanol plants.

Several promising projects aim to solve the problem of lignin degradation and bring us closer to converting lignocellulosic biomass into biofuels including an integrated biorefinery approach. This research includes the first-time isolation of a white-rot fungal enzyme that is capable of degrading high-molecular-weight lignin components.

Another research group is studying ways to convert swine and cattle manure into bio-fuels and hydrogen through a variety of methods involving fermentation and/or microwave pyrolysis.

Still another research group based in our department is finding new uses of bio-based products, including everything from developing enzyme-based self-cleaning coatings to the development of bio-based polymers than can be used in a wide range of consumer products.

Please visit the department Web site at www.bbe.umn.edu/ for more information about these initiatives, or contact Shri Ramaswamy, shri@umn.edu.

Bioenergy Initiatives at the University of Nebraska Thrive

Faculty members in the biological systems engineering (BSE) department have led the development of a university-wide energy sciences minor and are involved in discussions with a number of other engineering disciplines about a core curriculum for a Ph.D. degree in the college of engineering. The energy sciences minor has a plant and animal bioenergy systems track with collaboration among faculty members from the colleges of engineering, agricultural sciences and natural resources, and arts and sciences, and it is being well received.

In collaboration with the Nebraska Public Power Districts (NPPD), the University of Nebraska-Lincoln has formed the Nebraska Center for Energy Science Research (NCESR) to promote bioenergy research, education, and outreach. The BSE Department works closely with the NCESR. Nebraska is the only state in the United States that is served entirely by public power districts, and NPPD is the largest, serving all or part of 91 of the 93 counties in Nebraska; hence the NPPD has considerable influence in the energy activities in the state.
Four faculty members from the University of Tennessee’s Department of Biosystems Engineering and Soil Science (UT BESS) and their supporting staff are developing technologies for the Tennessee Biofuels Initiative (TNBI) (www.utbioenergy.org/TNBiofuelsInitiative/). TNBI is state-funded at $70 million U.S. with additional investment by Mascoma Corp.

A 5-MGY TNBI demonstration cellulosic-ethanol facility is scheduled to produce the first gallon of Grassoline in 2009. BESS develops technologies to supply 80,000 tons of switch grass for conversion to ethanol. The demonstration plant will answer scale-up questions for 60-plus MGY facilities.

BESS faculty is collaborating with nearby Department of Energy (DOE) Oak Ridge National Laboratory and Idaho National Laboratory and industry partners. Also, BESS faculty were recipients of a United States Department of Agriculture DOE Biomass Initiative Competitive Grant (approximately $718,000 U.S.) for integrated size reduction and separation; SunGrant (approximately $200,000 U.S.) for biomass deconstruction; and Oak Ridge National Lab (approximately $140,000 U.S.) for carbon sequestration research. Biofuel research and development programs in UT BESS are developing system-wide technologies, including:

- development of a bio-resource map for the state of Nebraska for use in siting future bio-refineries;
- development of a combined heat and power generation system based on gasification of distillers grains to provide the energy needs of an ethanol plant;
- characterization and utilization of co-products of bio-energy production, e.g., glycerol and distillers grains (oils, fibers, pigments, and sterols);
- modeling gasification of corn stover and distillers grain;
- production, characterization, and use of biodiesel;
- identification and characterization of oilseed crops and other feedstocks, e.g., hazelnuts, for biodiesel production; and
- production of ethanol, including pretreatment of cellulosic biomass, fractionation of corn before ethanol production versus separation of constituents in distillers grain, water use in ethanol production, and community strategies for capitalizing on ethanol production, testing engine performance on EB diesel blends.

For more information, contact ASABE member Ronald E. Yoder, ryoder2@unlnotes.unl.edu, and visit http://bse.unl.edu.

“Hazelnut oil,” says ASABE member Ronald Yoder, Biological Systems Engineering department head at the University of Nebraska, “has better characteristics and the potential for higher yield per acre than soybean oil.” Colorful hazelnut shrubs have figured in the university’s endeavors in the identification and characterization of oilseed crops and other feedstocks.

Virginia Tech’s Bioenergy Impact is Statewide

A cluster of nine faculty members in Biological Systems Engineering Department at Virginia Tech are leading bioenergy and production of value-added products in Virginia. The Center for Biodesign and Bioprocessing is established to facilitate the bioenergy research efforts. Ongoing activities are many.
Fueling Bioenergy Endeavors

- **High-yield hydrogen production from biomass**
  Hydrogen is widely believed to be a future energy carrier for transportation. A new technology is developed to produce high-yield hydrogen from starch and water at modest reaction conditions. This technology has great potential for solving the challenges of low-cost hydrogen production, storage, and distribution. For more information, contact ASABE member Percival Zhang, ypzhang@vt.edu.

- **Cellulose-solvent-based lignocellulose fractionation**
  A novel lignocellulose fractionation technology was invented to separate lignocellulose components at modest reaction conditions by using a cellulose solvent and an organic solvent. It releases high sugar yields from herbaceous and hardwood biomass and isolates high-value lignocellulose co-products. Contact Percival Zhang, ypzhang@vt.edu.

- **Biomass logistics**
  Efficient handling systems are being designed for the large round bale. The challenge is to design an efficient system of equipment to load, haul, and unload round bales and supply a bioenergy plant with a continuous flow of material. Contact ASABE member John Cundiff, jcundiff@vt.edu.

- **Thermochemical conversion of poultry litter to fuels and fertilizer**
  A biodegradable litter amendment material is developed to control the odor of the litter. The amended litter is then pyrolyzed in a fluidized bed reactor to produce bio-oil and slow release fertilizer. Contact Foster Agblevor, fagblevo@vt.edu.

- **Low temperature catalytic gasification of biomass to produce fuel and value-added products**
  A fractional catalytic pyrolysis process is developed to convert biomass feedstocks to low molecular weight phenols and synthesis gas. The synthesis gas is then used to produce “green diesel” while the liquid product can be used for high-value applications. Contact Foster Agblevor, fagblevo@vt.edu.

- **A holistic animal waste management practice for bioenergy production, nutrient recovery, and pathogen reduction**
  A significant enhancement of biogas production and struvite phosphorus recovery has been achieved through anaerobic digestion. A holistic approach is used to achieve high biogas yield, nutrient recovery, and pathogen reduction simultaneously. Contact ASABE members Zhiyou Wen, wenz@vt.edu, and Jactone Arogo, arogo@vt.edu.

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Rethinking ThermoChemical Conversion of Biomass into Biofuel continued from page 6

70 percent of swine manure volatile solids (dry mass) into crude oil, with heating values between 32 to 37 MJ/kg (13,800 to 15,900 BTU/lb). Similar energy production in waste streams for human wastes, lower but still significant oil yields, were also obtained with crop residues. When this technology is fully developed, the annual human and animal waste in the United States could yield more than 200 million barrels of crude oil, with a net zero carbon dioxide emission to the environment. This “green” energy potential and the avoided cost of waste disposal could further enhance the value of the fuel produced from TCC.

Gasification has been a widely applied process with lignocellulosic feedstocks. A direct hydrothermal process may be possible, but more research is needed. Pretreatment is currently a bottleneck in the conversion of cellulosic feedstock. TCC may hold a substantially greater potential to shorten the fermentation time of lignocellulose.

Traditionally, acid hydrolysis was commonly used to convert lignocellulosic materials to monosaccharides, but the high concentration of acids used in hydrolysis requires extensive waste treatment or recovery costs. The use of acid feedstock also requires a large capital investment for the necessary corrosion-resistant equipment. Relatively high temperatures are required to break down the crystalline cellulose to glucose by using dilute-acid hydrolysis, which causes decomposition of sugars at a significant rate and the degradation products, such as acidic acid, hydroxymethylfurfural, and furfural, significantly inhibit ethanol fermentation. Other commonly used pretreatment technologies include controlled pH, aqueous ammonia recycle, flow-through, and lime methods.

**Back to Mother Nature**

Lignocellulosic materials are the most abundant biomass available on earth. In the United States, one study showed that 1.2 billion metric tons (1.3 billion tons) of crop residue could be collected without decarbonating the soil. By natural design, lignocellulose has evolved to have some crystalline structures with closed rings, lacking open bonds to react with enzymes, thus resisting biological degradation. While scientists are engineering new enzymes that could break down lignocellulosic faster, the thermochemical conversion still has something important to offer: It can break down the long carbon chain much faster than biological means, typically on the order of minutes instead of days at present. The conversion of lignocellulosis biomass into biofuel requires a comprehensive approach employing science and engineering in biology, chemistry, and physics.

ASABE member Yuanhui Zhang is a professor in the Department of Agricultural and Biological Engineering, University of Illinois at Urbana-Champaign, Urbana, Ill., USA; yzhang1@uiuc.edu.
Agriculture to See Huge Impacts from the 2007 Energy Bill

Overshadows Farm Bill in its ag implications

On Dec. 19, 2007, President George W. Bush signed into law an energy bill that will have larger long-term impacts on U.S. agriculture than the pending Agriculture Bill, said Christopher A. Hurt, a Purdue Extension agricultural economist. By increasing the Renewable Fuels Standard to 136 billion L (36 billion gal) by 2022, the bill provides a roadmap for the production of renewable fuels from our nation’s farms and forests.

Hurt highlights the most important facts and potential implications from the new energy bill:
• Cornstarch ethanol will contribute 136 billion L (36 billion gal) per year of the total.
• About 51 billion L (13.5 billion gal) of this capacity per year will be in place by the end of 2008.
• It will likely be the 2009 crop before U.S. corn producers can meet the huge demands of the rapidly expanding corn ethanol plants.
• A much slower rate of growth in cornstarch ethanol may occur from 2010 to 2015 with annual growth rates of two to three percent per year.
• Cellulosic ethanol will become the dominant growth portion of the industry after 2010. Total cellulosic ethanol is expected to grow from zero to 79 billion L (21 billion gal) by 2022.
• Existing cornstarch plants will focus on adding cellulosic ethanol production capacity at existing sites. The cellulosic portion of the plant will use corn stocks or other crop.
• Grazing lands will be targeted to shift to fuel crops such as prairie grasses. This may develop in areas such as the mid-South and the western portion of the Great Plains.
• Conservation Reserve Program acres may largely shift toward cellulosic energy crops in areas of the country.
• Forests and woodlands may be shifted to energy crop in portions of the country.
• There will be a large search for new energy crops. Some of these may be non-traditional crop, such as sweet sorghums or tropical maize, or advancements of crops such as sugar cane.
• A large amount of research, development, and experimentation will occur to discover the most economic ways to produce these new cellulosic energy crops.
• Most of the crops will be land- and natural-resource-based, which means agriculture will be called upon to meet these enormous challenges and thereby reap the potential rewards.

For more information, contact Christopher Hurt, hurtc@purdue.edu.
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What roles do ASABE members play in bioenergy? The breadth of the answer may surprise you: sustainable production, harvest, and storage; feedstock characterization; processing; conversion; and testing and standards development. It spans the entire bioenergy production value chain.

Biofuels and bioproducts begin in fields, forests, or lakes as biology that converts the sun’s energy into a harvestable “feedstock.” ASABE members’ expertise in effective production and mechanized harvest systems remove the high labor requirements to produce and harvest feedstock – from grain and grasses to growth of many terrestrial and aquatic feedstock. Current U.S. ethanol for gasoline is mostly derived from grain (corn) that is produced, harvested, and supplied with systems perfected by years of solid engineering often attributed to members.

The same is true for biodiesel made from oilseed crops such as soybeans. Corn and soybean supplies have some degree of established feedstock specifications to benefit seller and buyer. This minimizes unpleasant surprises during transactions. Renewed emphases are on cellulose-based feedstock for energy. Challenges for sustainable production, harvest, and storage lie ahead – especially to economically supply crop residues, dedicated energy crops, and wood residues. The large number of potential sources and crops, estimated at 50 to 60 in the southeast United States alone, are often dissimilar enough to require different mechanized harvest systems. Opportunities abound.

Feedstock has various physical and chemical properties depending on the selected plant anatomy, growing conditions, and time of harvest. The quality of feedstock is important. Members have determined how various handling and storage systems affect the most efficient use of feedstock chemicals. For example, members determined that corn stover fractionation and storage method affected glucose production during enzymatic hydrolysis, which ultimately affects ethanol (EtOH) production. Corn cobs, leaves, and husks produce more than 300 percent more glucose than corn stalks. This raises engineering optimization questions. Should single-pass harvesters harvest grain and the highest EtOH yield stover components? Or is it more efficient to collect all stover residue for EtOH production, taking into account soil sustainability, EtOH production efficiency, and transport cost of stalks that yield less EtOH? Similar questions are raised with respect to other feedstock; is it more efficient to “cherry pick” the components that are most chemically-targeted for conversion?

Feedstock processing includes a wide range of “processes” that improve and prepare the feedstock for conversion to a biofuel or bioproduct. Categories of processes range from physical to chemical to biological. Processing is a value-added step that converts raw biomass to a safe high-quality feedstock with tighter-toleranced specifications. In collaboration with other ASABE members, my research involves improving size reduction and separation of cellulosic biomass feedstock. Energy-instrumented knife, hammer, and refiner disk mills are used while investigating chopping and grinding of switch grass, corn stover, and wheat straw under a range of moisture contents. Particle-size distributions were determined using ASABE-specified sieve designs and corrected for actual particle dimensions using image analysis. Resulting particle spectra may impact the degree of chemical degradation needed for conversion reactions. If size reduction takes place nearer the production field, this has implications of transport savings and the handling of a bulk product with tighter specifications compared to bales.

Biomass conversion to biofuel and bioproducts can take several pathways: chemical, biological, thermochemical, or combinations of these. Members use their broad knowledge of basic biology and engineering to ensure that the most efficient pathway is used for the particular biological characteristics of the selected feedstock. Driving factors include finding higher conversion efficiencies, newer conversion pathways, greater robustness of organisms, wider range of operating conditions, and greater economic viability. Innovative minds of ASABE members scour to find the right conversion pathway to ensure the success of bioenergy.

Testing of the biofuel or bioproduct for compatibility with equipment and the environment is another member strength. Performance testing enables accurate information for adjusting any step in the biofuel development process. Problems have been headed off before and during biofuel or bioproduct production bound for end-users. Many members apply expertise to develop published, consensus-based ASABE standards for the public good.

There are behind-the-scenes efforts to build on the achievements in biofuels, feedstock, and processing technology, and ASABE can take a greater leadership role within the growing bioenergy industry. Organization and packaging of current ASABE member efforts will help raise the visibility to potential members, conferences, and the associated bioenergy industry.

ASABE member Alvin R. Womac is chair of FPE–709 (Biomass Energy and Industrial Products) and professor of biosystems engineering at the University of Tennessee, Knoxville, USA; awomac@utk.edu.
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