S
ometimes as I watch a college athletic event, I hear the fans chanting, “We are State U!” As I have traveled to ASABE meetings from Halifax, Nova Scotia, to Tulare, Calif., and points between, I have thought about how “We are ASABE.” Each member is an integral part of our Society. Without members there is no Society, and without active members little, or nothing, is accomplished. Listed in the Society roster are 218 standing committees, 40 sections, eight communities, four councils, and one Board of Trustees. These comprise our Society structure and provide many opportunities for each member to contribute. Further, our Society structure is quite flexible, and new committees, sections, and communities can be proposed to address emerging areas or new initiatives, or to engage a larger segment of our membership in an area or activity that is not currently being adequately represented.

We are a Society of volunteers. We begin by voluntarily paying our Society dues because we find value in belonging that is at least commensurate with the amount we pay each year. But paying our dues is only the beginning. While we have an excellent and dedicated staff at our headquarters in St. Joseph, Mich., to conduct the daily business of the Society, the fuel that advances the Society is the time, energy, and ideas of the members. By committing to the belief that ASABE is a great organization worthy of our investment and our contribution in sections, on committees, in communities, and on councils, we ensure the vitality of our Society.

Throughout our long history, our strength has come from our members and their willingness to invest many hours in the tasks that, in aggregate, build the organization. To those of you who have made that investment—thanks! And to those who have yet to get involved: there are many opportunities for you to roll up your sleeves and help lead a great organization by contributing your energy and creativity.

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asabe conferences and international meetings

To receive more information about ASABE conferences and meetings, call ASABE at (800) 371-2723 or e-mail mtgs@asabe.org.

2010

June 13-16 9th International Drainage Symposium. (Held in association with the annual meeting of CSBE/SCGAB.) Quebec City, Canada.
June 20-23 ASABE Annual International Meeting. Pittsburgh, Pennsylvania, USA.
Sept. 12-15 International Symposium on Air Quality and Waste Management for Agriculture. Dallas, Texas, USA.
Nov. 14-17 TMDL 2010: Watershed Management to Improve Water Quality. Baltimore, Maryland, USA.
Dec. 5-8 Irrigation Symposium. Phoenix, Arizona, USA.

asabe endorsed events

2010

June 13-17 The Canadian Society for Bioengineering - Société canadienne de génie agroalimentaire et de bioingénierie (CSBE/SCGAB) XVIIIth World Congress (annual meeting). Quebec City, Canada. For information visit www.cigr2010.ca.
June 13-16 8th World Congress on Computers in Agriculture. (Held in association with the annual meeting of CSBE/SCGAB.) Quebec City, Canada. Visit www.cigr2010.ca.

2011

Sept. 21-23 11th International Congress on Mechanization and Energy in Agriculture. Istanbul, Turkey.
FEATURES

4 Mechanical Harvesting of Citrus
Reza Ehsani and Sajith Udumala
“Mechanical harvesting is necessary to stay competitive in today’s global fruit market. However … the cost of existing machines needs to be reduced and performance needs to be improved.”

7 Recirculation Technology
Tim Pfeiffer
The future of aquaculture depends on research. Like land-based farming, it must make the best use of limited water resources.

10 Quality Detection Gets Under the Skin
Renfu Lu and Daniel Guyer
Development of the next generation of sensors to assist specialty crop industries must increase profitability and ensure consumers of consistent high quality. Current sensor research on cherries, chestnuts, apples, and pickling cukes is “under the microscope.”

14 Developing Solar Power
James R. Fischer and Gale Buchanan
We must forge on to generate electrical, thermal, and transportation energy directly from the sun. But how?

18 Hands-On Engineering Gets a Leg Up
Kerri Ebert and Stacy Hutchinson
The Kansas State University ABC Design Teams bring agrability to their clients through experiential education.

Series: The Professional Engineer
20 Earning the Title
Dana Porter
“I am enthusiastic about the engineering profession, and a P.E. license is critical to my credibility …”

UPDATE

21 Squeezing more crop out of each drop of water

22 New composting facility turns waste into want

23 Miscanthus rhizome root harvester and planter unveiled

24 New, high-quality maize genome sequence will advance basic and applied research

26 FDA approves WSU researcher’s new food processing technology

27 Advanced engine-control system reduces biodiesel fuel consumption and emissions

28 New forest planning model could help protect stream water quality

DEPARTMENTS

2 From the President

29 Professional Listings

30 Take the Ag Engineering PE Exam … for free?
Jay Harmon
Florida is the second largest producer of orange juice in the world today, second only to Brazil. However, the production costs in Florida are nearly three times the production costs in Brazil. Reducing production costs is vital to price U.S. citrus products competitively and remain profitable in the global market. Harvesting accounts for about half of the production costs in U.S. citrus production, so mechanical harvesting could reduce costs by increasing the rate of harvest, and thereby increase profits for Florida growers. Mechanical harvesting research for citrus began in the 1950s to address the inadequate availability of labor. This research has been led by the Florida Department of Citrus, the USDA, and the University of Florida.

Harvesting mechanization involves removing the fruit from the trees, moving the fruit to a central location in the orchard, and then transporting it to a packing house or processing plant. The transportation part of citrus harvesting was mechanized early in the 1960s with the use of fruit-hauling trucks, called “goat trucks” (fig. 1), for transport within the orchard and trailers for highway transport. The removal of fruit from the tree is more difficult to mechanize, and research in this area has been ongoing since the late 1950s. Efforts toward fruit removal mechanization generally involve three different approaches: harvesting aids, mass harvesters, and robotic harvesters. Figure 2 shows one type of mass harvester used in Florida for citrus harvesting—a continuous canopy shaker. With respect to harvesting speed, mass harvesters are much faster than robotic harvesters and harvesting aids. However, mass harvesters were developed for the citrus processing industry and the juice market, where the appearance of the fruit is less critical, while harvesting aids and robotic harvesting were developed for the fresh fruit market.

**Harvesting aids**

Initial research indicated that fruit pickers spend a significant amount of their time on non-picking actions, such as climbing ladders or transferring fruit. Therefore, harvesting aids were designed to reduce these non-picking tasks. Single-picker and multi-picker positioning platforms were some of the harvesting aids designed in the past. Although these platforms helped to increase the efficiency of the pickers, the gains were not substantial enough to offset the cost of the harvesting aids. As a result, these platforms were rarely used for harvesting citrus in Florida.
With the recent labor shortage and the high cost of harvesting fruit, some manufacturers are taking another look into developing new harvesting aids that are capable of harvesting multiple crops. Figure 3 shows a new fruit suctioning system designed by Oxbo International Corporation. With this system, the fruit pickers’ only task is harvesting. This newly designed harvesting aid also addresses some of the issues that existed with previous harvesting aids. For example, fruit pickers are usually paid by the amount of fruit that they harvest, so this new system counts the number of fruit harvested by individual pickers. This feature provides an incentive for fruit picker to use the harvesting aid.

**Mass harvesters**

Mechanical mass harvesters differ based on the technique they use to remove the fruit from the tree. Typical approaches that mass harvesters use to remove fruit include shaking the trunk, branches, or canopy using mechanical attachments or air. Currently, Florida citrus growers use continuous canopy shakers (fig. 2). These harvesters shake the entire canopy to remove the fruit. However, only about 7 percent of Florida citrus is mechanically harvested. Florida’s citrus growers have been slow to adopt mass harvester systems because of lingering concerns related to non-fruit trash and potential

![Figure 2. A continuous canopy shaker citrus harvesting machine.](image)

![Figure 3. New harvesting aid developed by Oxbo International. (Photo courtesy of Oxbo International Corporation)](image)
effects on future yields. In addition, excessive shaking of the canopy can damage the trees. Visible injuries from mechanical harvesting include leaf drop, twig loss, scuffing of the bark on the branches, limb breakage, removal of flowers and young green fruit, and exposure of shallow roots at the soil surface.

A better understanding of the interaction between the shaker and tree will help to improve the design of continuous canopy shakers. Working toward this goal, CAD (computer-aided design) models of trees have been developed in the laboratory to study the behavior of canopy shakers (fig. 4). The simulation results showed that the stress in a tree increases with increasing shaking frequency. Research on using a variable-rate shaker to change the shaking frequency based on the size and cultivar of the tree is underway at the University of Florida.

Despite visible canopy damage, there is no historical evidence, except in the case of late-season ‘Valencia’ oranges, for tree mortality or loss of yield. However, growers remain concerned about damage resulting from the use of mass harvesters. In fact, mass harvesters were designed to pick fruit for the citrus processing industry, and fruit harvested using mass harvesters is usually not suitable for the fresh fruit market.

Robotic harvesters

Similar to mass harvesters, robotic harvesters are intended to reduce the cost of harvesting, but they are primarily designed for the fresh market fruit. Some of the challenges associated with robotic harvesters include identification of fruit within the canopy, maneuvering of the robotic arm around branches to pick the fruit, the slow harvesting rate, and the prohibitively high cost of these machines. Research is being done at various universities and companies to reduce the cost and increase the speed of robotic harvesting by using techniques such as multiple arms for harvesting, separating the harvesting task from the fruit-locating task, and designing fast-acting harvesting end-effectors.

Abscission compounds

In addition to the work on harvesting aids and harvesting machines, development of abscission compounds is ongoing. The bonding force of the fruit to the tree decreases naturally when the fruit matures. An abscission compound helps to further reduce this bonding force and can thereby reduce the force required to remove the fruit from the tree. This could improve the efficiency of current mechanical harvesters, improve fruit quality, and further reduce harvesting costs. Currently, registration of an abscission compound known as CMNP (5-chloro-3-methyl-4-nitro-1H-pyrazole) is underway, and special-use permits may be available for the 2010-2011 season.

Mechanical harvesting is necessary to stay competitive in today’s global fruit market. However, for mechanical harvesting of citrus to be effective, and to win acceptance from growers, the cost of existing machines needs to be reduced, and their performance needs to be improved. We have made substantial progress since mechanical harvesting research began back in the 1950s, but much remains to be done. The global demand for high-quality fruit and the competitive pressure to minimize production costs offer a serious challenge to researchers in the U.S. citrus industry.

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ASABE member Sajith Udumala is a graduate student in agricultural and biological engineering doing research on the canopy shaker, University of Florida, Gainesville, USA; sajith.jose@gmail.com.
With limited resources available to increase the wild-harvest fishing industry, the United States and foreign countries are expanding their aquaculture production. As a result, the production of farmed fish is eclipsing that of wild caught fish, and it will soon supply half of the total fish and shellfish for human consumption.

Between 2004 and 2006, the annual growth rate of the aquaculture industry was 6.1 percent by volume and 11 percent by value. Atlantic salmon and tilapia are good examples of industries where most of the product is farm-raised and production is expanding to meet the increasing demand. In addition, the United States currently imports 80 percent of its seafood, including 2 million tons of farmed products each year. That trend has been going on for years and, in the future, the domestic seafood market will likely see an even greater percentage of its products imported from foreign sources.

As per capita consumption of seafood increases in the United States and throughout the world, USDA Agricultural Research Service scientists and engineers are exploring solutions to some of aquaculture’s biggest challenges, including improving the health and growth efficiency of farmed fish, developing feeds that improve feed efficiency and reduce feed conversion ratios, substituting non-fish ingredients into formulated feeds, and conserving water by using water recirculation and reuse technology. This last point is important, but it may not be obvious: just like land-based farming, aquaculture must make the best use of limited water resources.
It’s all about the research

At the USDA-ARS Sustainable Tank Aquaculture Recirculating Research facility, located in the aquaculture park of Florida Atlantic University’s Harbor Branch Oceanographic Institute (FAU-HBOI) in Fort Pierce, Fla., research is ongoing to address the challenges. In a collaborative effort between USDA-ARS and FAU-HBOI, scientists and engineers are working to develop technologies for rearing marine fish in low-cost, energy-efficient, low-salinity recirculating aquaculture systems (RAS) that include innovations in water reuse, waste management, fish feeds, and energy use. Research has been conducted with species as diverse as the southern flounder, cobia, hybrid striped bass, and black sea bass. Most recently, research has focused on developing technologies to raise Florida pompano in low-salinity RAS from juveniles to market size.

The RAS units at the USDA research facility that are used for conducting research trials for finfish are designed with the objective of minimizing operational energy costs as well as water use. These systems use low-head propeller pumps and air lift pumps for moving water through the system and water treatment units. Moving bed biofilters, rotating microscreen drum filters, swirl separators, protein skimmers, and submerged bed filters are used for removal of solids and toxic metabolites (ammonia and nitrite), while UV sterilizers are used to disinfect the water of any potential parasites, harmful bacteria, and potential viruses. These systems are used to raise fish from hatchery size (~1 to 5 g, or 0.04 to 0.2 oz.) to stocking size (40 to 100 g, or 1.4 to 3.5 oz.). Daily energy draw of the systems is roughly 30 kW per day, and daily system makeup water (that is, the water needed to replace water lost) ranges from 2 to 8 percent of system volume.

In addition, large-scale, multi-tank, experimental RAS systems are used for replicated biological, engineering, and economic studies of the production of low-salinity finfish species. The facility includes two different four-tank RAS designs, each replicated four times, for a total of 32 culture tanks. Each four-tank system includes a microscreen rotating drum filter and protein skimmer for removal of solid and suspended wastes, a moving or static bed biofilter for ammonia and nitrite removal, supplemental oxygenation that is monitored and controlled using oxygen sensors and PLCs, microbubble aeration diffusers, centrifugal pumps and propeller pumps for water movement, UV sterilizers for return water disinfection, and degassing columns for CO₂ removal. Automated feeders supply feed to the fish in each tank at a range of feeding frequencies and feeding periods. Additional support facilities include a temperature-controlled feed storage building, an engineering and fabrication shop, and a 37.2 m² (400 ft²) analytical wet laboratory equipped with various water quality instruments, spectrophotometers, BOD and COD analyzers, solids analysis equipment, and Ethernet-enabled computers for monitoring water quality and data input and analysis.

Growing demands

Recirculating aquaculture systems (RAS) have been used for years in many parts of the world, for both commercial and experimental purposes, and they have been improving steadily. Several forces are driving the development of recirculating technology for aquaculture production systems, including the limited availability of water resources, more stringent environmental regulations to reduce water consumption and improve effluent water quality, and the need for greater control over the production environment with increasing biomass per unit volume of water.
With consumer demand for seafood on the rise, there is also a growing demand for a cleaner, greener, safer product. Open-water fish farming methods, such as coastal ponds and open-ocean cages or floating net-pens, raise concerns about pollution of the marine environment, conflicts with other coastal ocean users, waterborne diseases, and escape of non-native production fish. Land-based RAS provide an alternative to open-water farms that does not compete with other ocean users and reuses virtually all of the water that is put into the system. RAS can also be used in tandem with aquaponics—growing plants in water rather than soil—to produce a variety of herbs, fruits, and vegetables such as basil, tomatoes, lettuce, okra, and melons. These RAS can range from a small-scale urban system in a homeowner’s backyard to a larger, commercial-scale farm that grows both fish and produce, with several hundred thousand dollars in annual sales.

With the decline of capture fisheries and the increasing demand for seafood, U.S. aquaculture production must increase. However, the U.S. aquaculture industry is based mainly on production of freshwater finfish, with salmon being the only saltwater finfish cultured to any notable extent. In contrast, on a global scale, saltwater aquaculture contributes fully one-third of farmed production, and cultivation of saltwater species represents the fastest growing segment in aquaculture. Development and expansion of saltwater aquaculture in the United States is challenged by the high cost and limited availability of coastal land and water resources, effluent concerns, high production costs, restricted growing seasons, lack of quality seedstock, and limited knowledge of production strategies for these marine finfish. Many of these challenges can be addressed through research to develop intensive, energy-efficient recirculating aquaculture systems. A particular challenge is to increase the nutritional value of feedstuffs to increase nutrient uptake, lower feed costs, and reduce the amount of waste generated while promoting optimal growth and development, improved product quality, and production efficiency.

Reduced reliance on fish meal and fish oil from capture fisheries will enable increased production of fish feeds for sustainable aquaculture production. In addition, increased use of RAS will reduce water usage and effluent discharge to the environment. Improved technologies for waste capture and water remediation will result in sustainable effluent management, along with the possibilities for marketable by-products and decreased water usage. Improvements in cost and energy efficiencies will maximize profits per unit of volume production. These technologies will improve the global competitiveness of domestic producers by maximizing their production efficiency, minimizing waste production, decreasing energy and regulatory costs, optimizing product quality and safety, and providing clear value to consumers. And there are even larger benefits. Expansion of the U.S. aquaculture industry will reduce the U.S. trade deficit, increase job market opportunities for inland rural sectors, increase crop diversity, and enhance food biosecurity.

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We’ve come a long way to ensure fruit quality over the past few decades. Postharvest sorting has evolved from simple gravity-flow inclined surfaces for use by human sorters (fig. 1) to recent advances in fully automated technology that can detect internal defects and evaluate produce at rates of over ten items per second (fig. 2). Along the way, there have been sorting belts, sizing and elimination chains, physical techniques based on density or softness, electronic color sorting, and electronic imaging using visible and near-infrared (NIR) wavelengths for sizing and detecting surface and near-surface blemishes, among other techniques. All help ensure quality and consistency as well as reduce dependency on labor. The next generation of technology, which is able to “look inside” the commodity, is being extensively researched and is becoming commercially available. This new technology can determine sugar and acid content, identify internal defects, determine texture and maturity, and even evaluate food safety.

The USDA-ARS and Michigan State University (MSU) at East Lansing, Mich., have been actively engaged in development of the next generation of sensors to assist the specialty crop industries in increasing profitability and ensuring consumers of consistently high-quality products.
Our research is focused on nondestructive quality evaluation of fruits, nuts, and vegetables before, during, and after harvest. This includes applying state-of-the-art opto-electronic, electro-chemical, and mechanical technologies, combined with statistical analysis methods, for rapid detection, sorting, and grading of specialty crops for internal quality and defects. This article highlights several current research projects in our laboratories.

**Getting the bugs out**

Tart cherries are an important asset to the landscape and agricultural economy of Michigan as well as other regions. In addition to the long-standing challenge of ensuring a pit-free product, there are more recent concerns about land use and food safety—specifically, the challenge to grow a high-quality product with less chemical input. As a result, decreased ability to control pests in the field puts greater pressure on ensuring postharvest food safety and quality.

MSU is currently researching visible and NIR reflectance and transmittance spectroscopy and imaging for postharvest inspection of tart cherries to detect the presence of insects (fig. 3). Insect infestation creates changes in the chemical and physical properties of the fruit (while not always creating changes in the outward appearance that are detectable by current sorting techniques) that can be detected at specific wavelengths of light. Coupling these spectral changes with imaging technology has potential as a method to detect internal tissue damage (as caused by infestation) and ultimately sort for this defect.

**Appeal within the peel**

After a severe infection of blight in the middle of the 20th century, domestic chestnuts are making their way back onto produce shelves. As the chestnut industry advances from hobby growing to intense commercial production, there is a growing need to automate various aspects of production and processing. One such operation is quality determination and sorting. Chestnuts can possess various types of internal degradation as a result of physiological or pathological issues. However, in many cases, defective chestnuts continue to have an outward appearance equal to that of high-quality chestnuts, and sorting techniques are hampered by the thick outer peel.

Currently, the most common sorting technique is based on density in a water bath: good chestnuts have a tendency to sink, while those with defects float. This method is successful to a degree; however, it also results in unacceptable numbers of good nuts being rejected (hurting profitability) and some bad nuts being retained (hurting consumer markets). MSU is researching technology to determine chestnut quality by evaluating the emission of volatile compounds by chestnuts, as well as the use of advanced electromagnetic technology that can “see” through the shell.

Volatiles are a focus of investigation because deer and squirrels are experts at scavenging good chestnuts while leaving poor-quality nuts behind, without ever penetrating the peel. So far, research results have supported the “scavenger hypothesis” by showing that volatiles from the headspace around a good-quality chestnut differ from those of defective nuts. However, while differing volatile profiles could be demonstrated, the results were highly variable and developing a practical “sniffer” would be a significant challenge.

A more promising technique that’s currently being pursued is computed tomography (CT), which can spatially resolve tissue densities. An example of CT’s ability to accu-
rately detect abnormalities is presented in figure 4, which shows a whole chestnut, a physical slice of the nut, and the corresponding CT “slice” in the same plane of the same nut.

This research, which is demonstrating the capability of identifying and quantifying internal problems in chestnuts, coupled with cost-effective advances in CT technology in general, has exciting potential for future development.

**Seeing the light**

Generating about $1.5 billion in annual revenue at the farm gate, apples are an important commodity in the U.S. specialty crop industry. Before they can be shipped to the marketplace, apples for the fresh market need to meet quality grade standards (color, size, shape, firmness, and absence of defects). Today, computer vision technology is commonly used for sorting and grading apples for color, size, shape, and blemishes at the packinghouse. However, a good-looking apple does not guarantee a pleasant eating experience. The internal quality ultimately determines consumer satisfaction. In addition to appearance, fresh apples need to have good flavor (i.e., proper sugar and acid level), appropriate texture (firmness, crispness, or juiciness), appealing aroma, and absence of defects.

The USDA-ARS lab at MSU has been working on light scattering technology for assessing internal quality of apples, including firmness and soluble solids content (fig. 5). The technique is based on the principle that light propagation in the fruit is closely related to the density, tissue composition, and cellular structures. Therefore, spectral scattering and absorption characteristics can be used for quantitative assessment of fruit qualities, such as firmness and soluble solids content. In addition, computer simulations, based on radiation transfer theory that describes light transfer in turbid biological materials, have been developed to understand how photons (in quantum theory, light consists of packets of energy called photons) propagate in the fruit and how the fruit’s spectral scattering/absorption characteristics are related to its properties. The spectral scattering technique provides a new means for effectively assessing internal quality of apples and other horticultural products.

This light scattering technology has also found applications in other areas of food quality and safety inspection (e.g., milk composition, meat quality, pathogen detection, etc.).

![Figure 4. Internal defect detection of chestnut using computed tomography: (left) whole chestnut, (center) color image after cutting, and (right) CT “slice” from whole chestnut in the same plane as the cut.](image)

![Figure 5. A spectral scattering system for internal quality assessment of apples. (Photo courtesy of USDA-ARS)](image)
A special invited technical session on the technology is planned for the 2010 ASABE Annual Meeting in Pittsburgh, Pa.

**Hyper cukes**

Each year, American consumers spend billions of dollars on pickled products. A large percentage of pickled products are made from pickling cucumbers. Pickling cucumbers are grown in many regions of the United States, with Michigan being the largest producer. Pickling cucumbers are susceptible to internal damage due to adverse growing conditions, over-maturation, and mechanical stress resulting from improper harvest and postharvest handling. Internally damaged cucumbers tend to bloat during brining. Bloated cucumbers are characterized by soft or watery tissue, loose seeds, and hollow or split centers. Bloated cucumbers must be removed from the process because they are not suitable for making into pickles.

Although machine vision is currently used for sorting and grading pickling cucumbers and pickles, it only inspects external characteristics (color, size, shape, and surface defects). To address internal quality issues, the USDA-ARS lab has been developing a hyperspectral imaging system that operates in reflectance and transmittance sensing modes for inspecting both external and internal quality characteristics of pickling products (fig. 6). Hyperspectral imaging, which integrates conventional imaging (spatial) and spectroscopy (wavelength) techniques, acquires three-dimensional images (called 3-D hypercubes) of the product. Therefore, it greatly enhances our ability to assess properties and characteristics that are otherwise difficult to detect with either imaging or spectroscopy alone.

Hyperspectral imaging has shown great potential for food quality and safety inspection over the past decade. The USDA’s hyperspectral imaging system uses reflectance mode in the visible region to inspect the surface characteristics of each product item, and uses transmittance mode in the near-infrared region to detect internal quality or defects. The system has achieved overall classification accuracies of greater than 90 percent for pickling cucumbers and about 85 percent for whole pickles. Research is continuing toward a commercially viable system to sort and grade cucumbers and pickles.

Sensor technology is an area of ongoing research that has application to all specialty crops and to other products as well. Whether emulating human perception or sensing things that are beyond human ability, sensors are an exciting research area with the capacity to enhance the specialty crop industry. While the “next generation” of internal evaluation sensors is evolving, brainstorming for the next “next generation” is already underway. In the future, specialty crop sensing may include automated monitoring of insects and diseases in the orchard, harvesting aids that help human pickers make on-the-spot quality determination, sensors for automated picking systems, and more. Automated sensing will be an important contribution to the economic and environmental sustainability of the specialty crop industry.

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Cherry image © Maxpro/Dreamstime.com; chestnut image courtesy of Mario Mandujano; apple image © Atman/Dreamstime.com; cucumber image © Atman/Dreamstime.com.

![Figure 6. Hyperspectral imaging system in simultaneous reflectance and transmittance modes for inspecting external and internal quality of pickling cucumbers and pickles.](image-url)
Developing Solar Power

“Look up, young man, and grow up with the energy of the sun”

James R. Fischer and Gale Buchanan

In the 1880s, newspaper editor Horace Greeley exhorted young people to develop the American frontier: “Go west, young man, and grow up with the country.” Today, we need to encourage young people to grow their country’s energy future by developing solar power.

Why solar?

Three reasons:

1. The sun will be available for a very long time. In fact, astronomers estimate that the sun will be around for another several billion years—that’s just about forever.

2. The sun is a powerful source of energy. In just one hour, sufficient solar energy reaches the earth to supply the needs of our planet for an entire year. To put it in different terms, the total annual power needs of all humanity are approximately 16 terawatts a year; the sun provides a whopping 120,000 terawatts a year just to the earth’s land areas.

3. The sun is a ubiquitous source of energy. It’s available everywhere, to everybody, so there’s no cause for conflicts, as with land-based resources like petroleum.

In the beginning: the sun and fossil fuels

Fossil fuels (petroleum, coal, and natural gas) are solar energy that was captured by green plant photosynthesis millions of years ago. Humans have used fossil fuels for thousands of years: the ancient Persians used petroleum for lighting, and the Chinese drilled the earliest oil wells almost 2,000 years ago. Large-scale exploitation of petroleum is a recent development: the Russians drilled their first well in 1848, and the Romanians did so in 1857. In the United States, Edwin Drake drilled the first oil well in 1859 in Titusville, Penn. Demand for petroleum increased with the development of the internal combustion engine in the late 19th century: the four-stroke gasoline engine was developed by Nikolas Otto in 1860, the two-stroke gasoline engine was invented by Karl Benz in 1879, and the diesel engine by Rudolph Diesel in
1892. Today, petroleum accounts for over 40 percent of the total energy consumption in the United States.

Like petroleum, coal also has long history. In ancient China, coal was used for heating and cooking during the Han Dynasty (206 B.C. to 220 A.D.). In Europe, during the Roman period, coal began to be used for iron-working. During the industrial revolution, the steam engine replaced the water wheel as the primary source of motive power, and coal was the dominant energy source for generating steam. Following the invention of the electric motor by Michael Faraday in the 1820s and the development of central generating plants, in the 1880s, coal became the fuel of choice for electric power generation. The Energy Information Administration (EIA) estimates that there are 843 gigatons of coal reserves in the world, which at the current rate of extraction will last another 132 years. However, the use of coal has environmental impacts, including atmospheric CO2 (combustion of coal due to human activities is the largest source of this greenhouse gas), fly ash, sludge from flue gas desulfurization, and acid rain.

Natural gas is the third fossil fuel, after petroleum and coal. Natural gas provides one-fifth of all the energy used in the United States. The first gas well was drilled in 1821 in New York to obtain gas for street lighting, but natural gas was not a popular energy source for heating and industrial use until pipelines were constructed to distribute the gas. It is estimated that the United States has sufficient reserves of natural gas to last at least another 60 years, but there are questions about how easily it can be extracted from dense underground formations.

**It’s been a good ride, but …**

Today, we are drilling more but finding less petroleum. Globally, new discoveries of petroleum peaked in the 1960s. Each year since 1984, on a global basis, more petroleum has been consumed than new petroleum reserves discovered. In other words, we are steadily depleting a finite resource!

The world will eventually reach “peak oil”—the point of maximum global petroleum extraction, after which extraction will begin a permanent decline. Because it’s exceedingly difficult to know when that peak will occur, this is a hotly debated topic. However, predicting when the world will reach peak oil is less important than realizing that it will occur. At some point, the world’s remaining petroleum reserves will no longer be economically recoverable. In the meantime, as the reserves of readily available petroleum decrease, global tensions will rise. We’re starting to see this already, as relations between the major petroleum-consuming countries and the major petroleum-producing countries become strained. In fact, access to petroleum has been a factor in military conflicts since the 20th century, including both world wars. This will only get worse.

When do we start the process of achieving sustainable energy, and thereby achieve energy security? The answer is obvious: we must start now, while we still have sufficient petroleum to sustain us through the transition to alternative energy sources. During this transition, petroleum will remain an important source of energy, especially for transportation. However, it can’t be our only source of energy, not even for transportation. We must find clean, reliable, sustainable, and economical transportation fuels and reserve our remaining petroleum for critical purposes. We can do this before the oil runs out. Sheik Yamani, the former oil minister of Saudi Arabia, captured the essence of this transition when he said: “The Stone Age ended not because of the lack of stone. Undoubtedly the same will be true for the oil age.”

**Growing energy from the sun**

In terms of available energy, the remaining worldwide fossil fuel resources have been estimated at $0.4 \times 10^{24}$ joules. However, because of the constant energy from the sun, the world also has a renewable energy potential that exceeds $3.8 \times 10^{24}$ joules. This solar energy is nearly an order of magnitude greater than the fossil fuel resources, and it’s 8,000 times the total energy that humanity used in 2004.

Humans have used solar energy for centuries. For the past 200 years, we have done so indirectly, in the form of fossil fuels. Now we must generate our electrical, thermal, and transportation energy directly from the sun. How can we do this? Here are several approaches.

**Solar photovoltaics**

Photovoltaic (PV) cells produce DC electricity when incoming photons, such as sunlight, energize the electrons in the photodiode device. A decade ago, photovoltaic cells were on the order of 10 percent efficient. Today, research is enabling progress toward achieving 20 percent efficiency by employing copper indium gallium selenide (Cu(In,Ga)Se2) polycrystalline thin-film solar cells. Another process that is approaching 20 percent efficiency is this same material plus zinc oxide and cadmium sulfate (ZnO/CdS/CuInGaSe2).

A unique and valuable aspect of photovoltaic solar power is its application to small-scale and remote situations, such as opening and closing gates, illuminating signs, powering electric fences, pumping water, and providing ornamental illumination for gardens and walkways.

PV is one of the fastest growing renewable energy technologies (110 percent growth from 2007 to 2008, with Germany, Japan, and the United States accounting for almost 90 percent of that growth). Cleantech America, Inc., is planning California’s first utility-scale photovoltaic solar project to be approved under the state’s Renewables Portfolio Standard (RPS) program. Named CalRENEW-1, the solar farm is located in the city of Mendota in California’s Central Valley and will provide 5 megawatts (MW) of emission-free solar electricity. Similarly, Suntech Power Holdings, a
Solar thermal electricity

Solar thermal systems convert sunlight to heat, which is then used to produce electricity. Several collector designs are used, such as parabolic trough, power tower, dish, and Fresnel. These designs use one of two basic methods to generate electricity:

- In high-temperature, closed-loop fluid systems, the heated fluid is used to generate steam, which operates a standard steam turbine electrical generator. The energy capture efficiency is approximately 20 percent.
- In direct-heated Sterling engine systems, a Sterling engine, fixed at the focal point of a solar array using mirrors or lenses, is driven by the solar-heated expansion of air or other gases. A single solar dish and Stirling engine system installed at Sandia National Laboratory’s National Solar Thermal Test Facility produces as much as 25 kW of electricity, with a conversion efficiency of 31.25 percent. One of the largest solar power plants (500 MW) is in the Mojave Desert in California, powered by 405 ha (1,000 acres) of solar dishes.

Solar thermal energy can also be used directly for heating applications. Three types of collectors are commonly used:
- Flat plate collectors are usually used for solar water heating systems in homes and for space heating. The collector heats a liquid as it flows through tubes in or adjacent to the solar absorber. Space heating can be achieved with flat plate collectors in which air is heated by the absorber plates.
- Evacuated tube collectors consist of parallel rows of transparent glass tubes that contain metal tubes fitted with fins and coated with a material that absorbs solar energy. These systems can achieve temperatures of 170°F to 350°F, which makes them appropriate for cooling and industrial applications.
- Integral collector storage systems preheat water using black-painted tanks or tubes for conventional water heating systems. These simple systems are best suited in non-freezing environments.

Solar lighting

Outdoor solar lighting uses PV cells to convert solar energy into electricity, which is stored in batteries until needed at night. Indoor solar lighting can be produced directly from sunlight through collectors located on roofs. These collectors focus sunlight light into optical fibers that are piped throughout the building and connected to special light fixtures. Hybrid light fixtures are equipped with photosensors that automatically balance their electrical input with the solar input to maintain uniform lighting in the room.

Photosynthesis

Photosynthesis is a natural process driven by solar energy that produces oxygen, glucose, and much more.

The end product oxygen is necessary for all life, and the end product glucose is the building block of biomass, which can be processed into feed, fiber, energy (i.e., electricity and transportation fuel), and products.

Photosynthesis captures over 100 terawatts of solar energy annually. Because of the importance of this process for all life, the diversity of the end products, and the regenerative capacity of biomass, this application of solar power deserves much more study.

Biomass

The pressures to produce sufficient high-quality biomass (food, feed, and fiber) are not new to farmers, forest managers, scientists, and engineers. However, that pressure now has an added dimension—the production of energy and biobased products.

Over the past two centuries, the agricultural and forestry industries have increased their production each time society has demanded it of them, and they have done so in ways that are increasingly responsive to environmental and economic concerns. For example, the Green Revolution substantially increased the world’s capacity to produce food while the world’s population nearly doubled.

Because of the distributive nature of solar energy, this planet has a great capacity for agricultural and forestry production over a wide range of climate and geography. Can agriculture and forestry produce biomass energy and biobased products and still meet, or even exceed, their ongoing responsibility for food, feed, and fiber? The answer is yes, if:

The biomass producing industries work together. These industries are in a unique position, not only because of the potential and diversity of the energy products they produce (liquid, electrical, and thermal) but also because these industries produce bioproducts that can be major competitors to petrochemical industry products, such as plastics.

The production of biomass products is sustainable. Aside from land requirements, water and various plant nutrients could become limiting factors. In achieving full sustainability, all these factors must be taken into consideration. These concerns do not mean that biomass may not contribute to addressing the energy situation, but we need to recognize that biomass is not an unlimited resource. As with all resources, the economical, social, and environmental issues should be addressed before implementation – something that was not done in the development of petroleum.

The science of biomass production increases. Developing biomass as an energy source requires research to discover potential applications and minimize environmental impacts. Just as research enhanced the productivity of plant
species for food, feed, and fiber, there is an equal and perhaps greater potential for improvement of plants for energy production. To make this potential a reality in our future, we must do the research now.

Many potential energy crops, such as elephant grass, *Miscanthus*, and switchgrass, are perennials, which means that their production does not require annual tillage of the soil. Such crops save energy, because annual tillage is not required, and they provide an excellent means of strengthening conservation of our soil and water resources. Other areas of bioenergy and bioproducts research include:

- Expansion of the catalog of species that can be used for fuels and biobased products.
- Improved breeding systems for perennial C4 grasses. Most species that are likely to be used as dedicated energy crops, such as switchgrass, are self-incompatible and therefore not amenable to development of true breeding lines for hybrid seed production. Basic studies of the mechanisms of self-incompatibility in the grasses would be very useful for future breeding programs.
- Evaluation of all species in the USDA-ARS National Germplasm Repository for desirable energy and product potential.
- Identification of new species for energy and product development potential.
- Identification of herbicides that can be used during establishment of energy crops.
- Identification of pests and pathogens that can threaten energy crops, including surveys of genetic diversity for natural resistance to such pests and pathogens, and development of pesticide management practices.
- Identification of optimal methods for long-term storage of harvested energy crops.
- Development of crops that accumulate only sugar or starch, such as sugarbeet, sugarcane, and sweet sorghum for sugar, and potato and cassava for starch.
- Development of a systems approach to production, harvesting, and processing.

**Just the facts**

Sergeant Joe Friday of the long-running TV series “Dragnet” was famous for demanding “just the facts” when he investigated a case. Here are just the facts:

**Fact No. 1:** Fossil energy is finite.

**Fact No. 2:** The world has a growing thirst for oil that is already unsustainable. Globally, more than 80 million barrels are consumed every day. As the developing world continues to industrialize, global consumption is projected to increase to 96 billion barrels per year in 2015, 102 bb/y in 2020, and 113 bb/y in 2030.

**Fact No. 3:** A handful of countries control most of the proven petroleum reserves (76 percent is controlled by OPEC member states).

**Fact No. 4:** The known oil and gas fields are maturing, new fields are not being discovered fast enough to keep up with demand, and the new discoveries are in locations that are difficult to develop. The U.S. Geological Survey reported that the U.S. consumed 27 bb/y in the last five years, but we discovered only 3 bb/y – a fraction of our consumption.

**Fact No. 5:** Experts are saying that we will reach global “peak oil” in the foreseeable future—but how much of the future is ever foreseeable?

**Fact No. 6:** Sustainable living does not equate to a lower standard of living.

**Fact No. 7:** There is no single solution to the energy dilemma—no silver bullet. It will take multiple approaches, and many small solutions—call it silver buckshot—to achieve a sustainable energy solution for our planet.

**Fact No. 8:** The sun is the ideal energy source for our planet because of its many potential energy applications, its ubiquitous availability, and its amazing versatility: it can be stored as seeds or as biomass and converted into heat, electricity, bioproducts, and biofuels.

**Fact No. 9:** The full potential of solar energy will not occur without additional basic research that unlocks the secrets of energy creation, storage, and transformation. Agriculture and forestry have a responsibility to be part of this process.

**Fact No. 10:** Achieving global, sustainable energy—that is, real energy security—is the greatest challenge facing civilization.

Now that we have the facts, let’s begin the process that will bring about a future in which energy is clean, abundant, sustainable, and affordable.

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Background image © Cammerayda/Dreamstime.com
When it comes to retention of learned material, experts agree that experiential education allows students to engage more completely in the learning process while offering some control over the direction and flavor of a chosen project.

Kansas State University’s Department of Biological and Agricultural Engineering has structured a Biological Systems Engineering Senior Design Course (BAE 536) to integrate experiential learning into students’ final semesters of college course work. Client-based interaction between students and their customers with real-world design problems offers seniors a more meaningful capstone experience than could be produced with classroom work alone.

The course uses a self-paced, laboratory-based, student-team approach to solve design problems that may involve equipment or systems used to produce food, fiber, or energy; to ensure environmental quality; to perform damage remediation; or to conserve natural resources.

During the Fall 2007 semester, one of the BAE 536 teams chose to work with the Kansas AgrAbility Project, a USDA-funded Extension program based in the K-State BAE department that assists farmers with disabilities, and a western Kansas farmer who experienced significant upper body mobility and range-of-motion limitations. Their client’s problem: safely entering and exiting his four-wheel-drive, articulated tractor.

The client was a row-crop farmer whose lifetime of work had taken a physical toll on his body. He had severe rotator cuff problems in both shoulders caused by years of overcompensating for his bad knees. By the time the student designers met him, he had undergone knee surgery, which greatly enhanced his lower extremity mobility. The rotator cuff damage, however, was irreversible. Unable to lift either of his arms above waist level, he had to place his left hand under his right elbow and push his right forearm up to reach the handrail on the tractor ladder. Because the motion caused him to lose balance, he leaned against the wheel hub of the four-wheel-drive articulated tractor, and then pushed off with his legs once he had hold of the handrail. The high-end solution to his problem was a $5,000+ mechanical tractor lift designed to assist farmers who are paralyzed. However, the lift was too expensive, not to mention more technology than he needed. His AgrAbility case worker sought a more low-tech solution.

Enter the ABC Design Team from K-State’s BAE 536 course. The students, Emily Beck, Anthony Mignano, and Lindsay Ott, traveled to the farm to interview their client and his wife, and take pictures (still and video) and measure-
Back in the BAE department’s on-campus workshop, the team researched and designed a spring-loaded, retractable extra step, with handles, for the tractor. The new design halved the distance from the ground to the first step, thereby eliminating the balance issue. Because the farmer still had strength in his arms, just limited mobility, the spring had to be set so he could lower the step with his hands without having to raise his hands over waist height. Several lab hours were spent experimenting with the spring constant. In addition, because the step was to be mounted on a tractor, the student design team determined that the spring must be protected from the elements, so they designed a housing that allowed access for maintenance but could also be sealed to prevent weather extremes from damaging the spring. Their experiments included testing tube-enclosure configurations as well as construction of a wooden test model.

With testing completed and the extra step and handles constructed, the students returned to the farmer’s home to mount their invention. With the use of their client’s tools and assistance from a neighbor with a welder, the design team was able to install the extra step in a single afternoon.

Following installation, their client could stand straight, hold on to the new handles while raising his leg to reach the new step, and then lower that step with his leg. With the handles at waist height, he didn’t lose his balance or need to lean on the wheel hub. When he reached the top of the ladder, the spring retracted the new step so that it was even with the original step, which eliminated the hazard of damaging the step by catching it on field debris.

The student team left knowing that they had made a positive impact on their client because they had worked through the problem-solving process together. Today, all three students are attending graduate school in Biomedical Engineering. Emily (Beck) Mangus and Lindsey Ott are studying at the University of Kansas, and Anthony Mignano is studying at Drexel University.

Design courses offer real real-world experience

One of the intangible benefits of an experiential learning course like BAE 536 is the opportunity for students to get to know real people and to help those people solve real problems. The ABC Design Team from fall 2007 learned from their initial interview that both their client and his wife held bachelor’s degrees from Fort Hays State University. From the many employment options available to them upon graduation, they had both chosen to farm. As a result of this career choice, ABC’s client found himself with physical limitations caused by years of farm labor. Nevertheless, he continued to find the work rewarding, even as it took a toll on his body.

As the ABC Design Team worked through an installation complication at the farm and determined the need for a welder, they also experienced the benefits of living in a tightly knit rural community. Their client’s neighbor (five miles away) had a welding shop, and he was happy to offer his expertise. Everyone became acquainted over the welding task, and the conversation started to flow. The team members described their class experiences, and the welder talked about his favorite pastime—constructing toys from scrap metal. In addition, two of his sons had attended KSU, and one was a graduate of the BAE department!

Since the original ABC Design Team’s experience in 2007, two additional teams have worked with AgrAbility Project farmers. The 2008 team assisted a commercial vegetable grower, who suffered from severe back and shoulder damage, by designing and constructing a raised garden bed that eliminated the need to bend and stoop to plant and harvest low-growing vegetable crops such as lettuce, spinach, and leeks. In 2009, a third team began working with a farmer who lost a leg in a farm accident. Their task is to help him access his combine. As we go to press, this project is still in the design process. When the students have finished the project, we can expect another useful solution that improves the life of another hard-working farmer.

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ASABE member Stacy Hutchinson is associate professor, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, USA; silhutch@ksu.edu.

ABC Design Team and their client, left to right: Alvera Davison, Kent Davison, Emily Beck, Lindsay Ott, and Anthony Mignano.
How has my PE helped me? Becoming licensed has provided me a sense of personal and professional accomplishment. I’ve earned the title “Engineer.”

I grew up on a farm in the Texas Panhandle, where I developed an appreciation for production agriculture, food safety and security, environmental quality, animal health and welfare, and safety and quality of life for people living and working in agricultural settings. Agricultural engineering allows me to apply my agricultural experience and my engineering aptitude and knowledge to find practical solutions to meet specific needs in these areas.

Through my applied research and extension programs, I evaluate and promote appropriate applications of irrigation technologies and best management practices to support agricultural production under water-limited conditions. I also help agricultural producers select technologies that are well suited to their operations and that manage irrigation efficiently to conserve water and/or maintain productivity and profitability.

I am blessed to work with really great people—agricultural producers, irrigation professionals, consulting engineers, and research and extension faculty.

I took the AG PE exam to support the profession of agricultural engineering and to expand my professional opportunities. I am enthusiastic about the engineering profession, and my P.E. license is critical to my credibility as I promote professionalism and licensure to students and colleagues.

As an engineer working in production agriculture and related areas, I can see the immense need for agricultural engineering expertise. Emerging technologies and issues in agricultural production and processing promise continuing challenges and opportunities for agricultural engineers.

I want to encourage others to maximize their professional opportunities through licensure. As agricultural engineers, we have an obligation to promote professionalism in general and our agricultural engineering profession in particular.

There are needs that agricultural engineers are better or uniquely qualified to address, including challenges and opportunities in production agriculture; food, feed, and fiber processing; and related environmental and safety concerns. I believe it is important for us to expand the public awareness, accessibility, and availability of our agricultural engineering expertise to meet these needs.

After recently attending a PE Exam Writing meeting in Clemson, this important topic is still very fresh on my mind. It presents a worthy challenge for me to verbalize WHY the PE exam matters. It’s not enough to say, “It just does!” But, in a nutshell, “It really does!”

ASABE member Dana Porter passed the AG PE exam in 1994 and became registered in 1995; email her at d-porter@tamu.edu.
Squeezing more crop out of each drop of water

In Brief: Studies in China and Colorado by Agricultural Research Service (ARS) scientists and cooperators have revealed some interesting tactics on how to irrigate with limited water, based on a crop’s critical growth stages.

Laaj Ahuja, research leader at the ARS Agricultural Systems Research Unit in Fort Collins, Colo., and colleagues conducted the irrigation studies. For one example, wheat in China, they found it best to use 80 percent of the water for wheat’s two critical growth stages. In Colorado, it was best to use 80 percent of the water for corn’s critical flowering and grain filling stages.

Other tactics for putting limited water to best use are to irrigate only part of a field, skip the pre-plant irrigation for corn, delay irrigating until up to half of the soil water is depleted, and wet soil to no more than 70 percent of field capacity.

Ahuja and his colleagues came up with the findings in China by combining the ARS Root Zone Water Quality Model (RZQWQM) with the Decision Support System for Agrotechnology Transfer (DSSAT) crop growth modules. While the combination of models has been used in other experiments to test alternative water and nitrogen management practices, this is the first time these models have been used to evaluate crop responses to lack of water across critical crop growth stages, and the first to use long-term weather data.

In Colorado, they used the models for simulations, relying on local weather records dating back to 1912. In China, the simulations used records from 1961 to 1999.

The scientists also found that farmers irrigating in China could cut back their nitrogen fertilizer use by a third, thereby reducing nitrate leaching by 60 percent without affecting crop yields.

The experiments demonstrated that crop simulation models enable fast and inexpensive transfer of technology from research labs and experimental stations to farmers’ fields. Coupled with local field experiments, they proved to be an excellent tool for making the best use of limited water.

For more information, contact USDA-ARS public affairs specialist Don Comis; Donald.Comis@ars.usda.gov.
New composting facility turns waste into want

In Brief: “Waste not, want not” has taken on new meaning with the opening of a composting facility at Iowa State University (ISU). Now waste generated across the university is turned into a valuable “want” to be used in a variety of ways.

Iowa State wants to be a leader in sustainability, and this compost facility contributes to that goal,” says Mark Honeyman, professor of animal science and coordinator of ISU’s research farms. “Composting is a great way to demonstrate an alternative use for manure, and the end result is an organic, usable product on campus.”

The ISU facility, which can handle more than 10,000 tons of compost-ready wastes annually, was planned as part of the new ISU Dairy Farm to handle solid dairy manure in an environmentally responsible manner. While the majority of product comes from the nearby Dairy Farm, there are many other sources.

The compost facility was constructed west of the Dairy Farm in late 2008 and was fully operational by the fall of 2009.

To reduce the risk of runoff and leaching, all operations occur inside seven large hoop barns. Products coming into the compost facility include manure and bedding from ISU farms, yard waste, greenhouse waste, biomass research waste, and food waste from campus dining facilities.

The process begins when nitrogen-rich manure is mixed with carbon-rich campus yard waste, cornstalks, or livestock bedding to make windrows. The proper mix balances carbon and nitrogen at the correct moisture and density to promote aerobic microbial decomposition, which reduces the volume of materials by about half over an eight-week period.

The windrows are turned and aerated periodically to promote composting and minimize odor. “A well-run composting facility should not generate odor,” Honeyman says. “This is an alternative to field application of manure and superior to stockpiling manure and other waste materials during times when field application isn’t possible because of weather conditions.”

The facility generates about 100 tons of compost each week. Finished compost is cured and stored until ready to be used. The compost is blended with sand and soil to create amended soil for landscaping around new construction projects, existing buildings, and planting beds across campus, including Reiman Gardens.

Compost is available to researchers for amending the soil structure in horticultural and agronomic plots. It also is being tested as bedding for ISU dairy cows.

The compost facility is a self-supporting service unit. All material brought to the facility is weighed on an electronic scale. Compost leaving the site is weighed and charged to the department using the material.

“We are working hard to make the project not only resource sustainable but also budget sustainable,” says Tim Goode, compost facility superintendent. “We have structured the fees to be advantageous for the departments supplying the material, as well as those using the finished product.”

Only waste material generated by the university is used. The resulting compost is not available to the public.

“I think it is quintessential for an agriculture-focused, land-grant university to have this kind of project,” Honeyman says. “It serves as a learning center for students, extension staff, agriculture and engineering research projects—and it’s all right here on campus.”

For more information, contact Melea A. Licht; mreicks@iastate.edu.
**Miscanthus rhizome root harvester and planter unveiled**

**In Brief:** After years of research and collaboration, a Miscanthus rhizome regeneration harvester and planter system has been developed and was unveiled for the first time at the University of Illinois Bioenergy Feedstocks Symposium.

A new harvester and planter machine package is the result of a three-year collaboration between the University of Illinois, Tomax Ltd., and Bermuda King USA. This machinery can lower the cost of Miscanthus rhizome production by up to 40 percent and create opportunities for Miscanthus to be used more widely as a high-yield bioenergy crop.

Gavin Maxwell, Tomax Ltd.’s senior bioenergy consultant, said, “Bioenergy feedstock processors require security for supply and unless we dealt with regeneration and planting issues for Miscanthus, we simply couldn’t make progress.”

Miscanthus rhizome cultivation is a labor-intensive process involving multiple machines and costly manual selection and grading.

“The collaboration team had a very clear objective when beginning the design process of the harvester and planter,” Maxwell said. “Our goal was to remove manual labor, integrate the digging and grading process, increase soil separation, and improve both quality and volume to substantially reduce the cost of vegetative rootstock propagation.”

The result, the Rizomgen™ planter and harvester package, is expected to save 50 percent on existing rhizome harvesting and planting costs.

Recent trials in the United States have demonstrated a 200 percent increase in rhizome collection over manual systems—allowing the opportunity for regional nurseries to more efficiently expand to meet the demand for both solid and liquid fuel conversion.

The new planter demonstrates a more uniform stream of rhizomes, enabling plant placement at a rate that matches rhizome weight, quality, and ground conditions. The four-row planter incorporates separate feed hoppers and placement channels, enabling it to be used for both two-row nursery work and larger-scale plantations.

The harvester does bulk lifting of rhizomes on a continual basis with a patented one-pass digging head and oscillating de-soiler. Rhizomes exit via a bulk side discharger that conveys rootstock to an adjacent trailer. The speed of extraction allows faster transfer of rhizomes to storage, which is a real benefit given the seasonal weather restrictions and narrow window of time that may prevail during the rhizome winter dormancy period.

The nursery package is also supported by a software management package that allows nurseries to register and trace energy crop production.

The harvester and planter package is now available for licensed U.S. and EU nurseries and will be available for expanding grower crops for the 2011 season.

Timothy Mies, deputy director of operations at the Energy Biosciences Institute at the University of Illinois, said, “When this project started, the propagation of rhizomes was done with shovels and lots of manual labor. These machines will take Miscanthus production to a new level.”

For more information, contact Jennifer Shike, media communications specialist, College of Agricultural, Consumer and Environmental Sciences, University of Illinois; jshike@illinois.edu.
New, high-quality maize genome sequence will advance basic and applied research

In Brief: The completion of a high-quality sequence of the maize (corn) genome was announced as a cover story of Science. This new genome sequence reports the sequence of genes in maize and provides a detailed physical map of the maize genome. This map identifies the order in which genes are located along each of maize’s ten chromosomes and the physical distances between those genes.

Information provided by the new maize genome sequence includes the locations on chromosomes of interesting, repeated sections of DNA (called centromeres) that are responsible for the faithful inheritance of those chromosomes by daughter cells during cell division.

This new genome sequence represents a major breakthrough in genetics because it promises to advance basic research of maize and other grains, and help scientists and breeders improve maize crops, which are economically important and serve as globally important sources of food, fuel, and fiber. The resulting improved strains of maize may, for example, produce larger yields; show resistance to disease; offer efficiencies in nitrogen use that would enable farmers to reduce applications of costly, polluting fertilizers; and tolerate changes in rainfall or temperature accompanying climate change.

The research team and its funding

The new maize sequence was produced by a consortium of researchers that was led by the Genome Sequencing Center (GSC) at Washington University in St. Louis, Mo., and included the University of Arizona, Iowa State University, and Cold Spring Harbor Laboratory in New York. This sequencing project was part of a joint Department of Energy/USDA/National Science Foundation (NSF) effort that was funded by NSF under the auspices of the National Plant Genome Initiative (NPGI).

The NPGI, which began in 1998, is an ongoing effort to understand the structure and function of all plant genes from the molecular and organism levels to interactions within ecosystems. The NPGI focuses on plants of economic importance and plant processes of potential economic value.

A cross between two inbred plants (left and right) produces a more vigorous and productive offspring (center), with significant practical advantages. The new maize genome sequence is expected to lead to a full understanding of the genetic basis for maize growth and development. This information will be used to tailor maize varieties to thrive in new environments and to generate new products. (Photo courtesy of Jun Cao and Patrick S. Schnable, Iowa State University, reprinted by permission from Springer-Plant Sciences)
“Production of a high-quality maize genome sequence was a high priority for the NPGI from the beginning,” said Jane Silverthorne of NSF. “This accomplishment builds on technological advances and basic research into maize biology that were essential to the design of the most cost-effective strategy to assemble and anchor the genes onto the genetic and physical maps.”

Real-world applications

Two other NPGI-funded studies were enabled by the new maize sequence. One produced a so-called HapMap of the maize genome, which describes the genetic differences between various strains of maize that are currently bred around the world. This resource will help researchers identify the genes that control various maize traits.

The other NPGI-funded study builds on the new maize genome sequence by identifying a surprisingly widespread biological process that determines the level of expression of certain genes present in hybrid strains of maize.

“Sequencing the corn genome provides scientists with new information and tools to access the vast array of genes available to improve corn,” said Kay Simmons of the USDA-ARS. “This new sequence information can be exploited to translate basic discoveries to the field for the benefit of corn growers, the corn industry, and consumers. It will pave the way for the development of maize breeding programs that will improve the quality and quantity of maize crops, and thereby benefit people throughout the world.”

Because maize has served as a model plant for basic genetics research for the last 100 years, the completion of its genome sequence has important implications for basic research. In addition to advancing research on maize, the maize genome sequence is also expected to advance other cereal genome sequencing projects, such as those for wheat and barley.

A daunting task

The maize sequencing project, which was initiated in 2005, is a notable achievement because it was completed quickly and because the maize genome is among the most challenging genomes sequenced to date. The complexity of the maize genome is partly due to its size: with 2.5 billion base pairs covering ten chromosomes, the maize genome is almost as big as the human genome and the largest plant genome sequenced to date.

The complexity of the maize genome is also partly due to the fact that about 85 percent of its DNA is composed of transposable elements—segments of DNA that can move between locations. “Transposable elements are found in all organisms, but were discovered in maize by Nobel Prize winner Barbara McClintock more than 60 years ago,” said Rob Martienssen of Cold Spring Harbor Laboratory. “It is a remarkable achievement to be able to visualize these elements in such detail in the genome sequence.”

For more information, contact Lily Whiteman, National Science Foundation; lwhitema@nsf.gov, or Jennifer Martin, USDA; jmartin@nifa.usda.gov.
FDA approves WSU researcher’s new food processing technology

**In Brief:** Imagine a salmon filet that looks, tastes, and is as nutritious as freshly cooked salmon but has a shelf-life of more than six months. A new technology developed at Washington State University (WSU) will make that dream a reality.

For the first time ever, the U.S. Food and Drug Administration has approved the use of microwave energy for producing pre-packaged, low-acid foods, a major milestone that clears the way for its commercialization. The technology developed at WSU could revolutionize how we preserve and process food.

ASABE member Juming Tang, a professor in the WSU Department of Biological Systems Engineering, led a team of university, industry, and U.S. military scientists to develop the technology. The outcome results in food with a longer shelf life as well as better flavor and nutritional value compared to more traditional processing methods such as canning.

“New processes for producing shelf-stable, low-acid foods must pass rigorous reviews by the FDA to ensure that the technology is scientifically sound and the products will be safe,” Tang said. “We patented our system designs in October 2006 after more than ten years of research. We spent another three years developing a semi-continuous system, collecting engineering data, and microbiologically validating the process before receiving FDA acceptance.”

The team’s microwave sterilization technology immerses packaged food in pressurized hot water while simultaneously heating it with microwaves at a frequency of 915 MHz—a frequency that penetrates food more deeply than the 2450 MHz used in home microwave ovens. This combination eliminates food pathogens and spoilage microorganisms in just five to eight minutes and produces safe foods with much higher quality than conventionally processed ready-to-eat products.

The project has been funded from a variety of sources and a consortium of industry members that include Kraft Foods, Hormel, Ocean Beauty Seafoods, Rexam Containers, Ferrite Components, and Graphic Packaging. The WSU team also worked closely with process authorities of the Seafood Products Association in Seattle and Hormel to establish validation procedures and in preparation of filing documents. In addition, faculty members from other WSU departments, particularly Food Science, contributed to the success of the project.

“The team’s collective efforts have created a new food processing technology that will benefit both the commercial sector and our military personnel worldwide with a wider variety of high-quality, shelf-stable foods,” said Gerald Darsch, director of the U.S. Department of Defense Combat Feeding team. “It is a tremendous accomplishment.”

Evan Turek, senior research fellow at Kraft Foods, said Tang’s new technology will make a huge difference for the food industry. “Since the introduction of industrial microwave ovens in the late 1940s, the food industry has been interested in exploiting the rapid heating capability of microwaves to improve the quality of canned food,” he said. “The technical issue has always been ensuring uniform and reproducible heat treatment. Dr. Tang had a vision about how this might be overcome, and with his leadership and the engineering prowess of his research staff and students, a protocol for practicing and validating microwave sterilization was established.”

WSU officials agreed. “This is a great example of how research universities produce breakthroughs that make an immediate impact on our nation and world. This new technology promises significant advances in food safety and quality,” said Howard Grimes, vice president for research.

Dan Bernardo, dean of the WSU College of Agricultural, Human, and Natural Resources, also said the impact will be dramatic. “There have been very few advances leading to FDA accepted food processing technologies in recent history,” he said. “The FDA’s approval of this new technology could revolutionize the way we process and preserve food, ensuring food safety, increasing its longevity, and maximizing the retention of its flavor and nutrition.”

Ralph Cavalieri, director of the WSU Agricultural Research Center, said Tang’s research has global benefits. “It is important across a range of applications,” he said, “from feeding astronauts on long-term space missions to transporting food to areas where people are unable to feed themselves.”

Dr. Tang’s research also has received support from Washington State’s Congressional delegation, especially Sen. Patty Murray. “This is great news for WSU, our growers, and American food processors,” Murray said. “It will help our growers and processors stay more competitive in the global marketplace and increase food safety for consumers.”

For more information, contact Kathy Barnard; kbarnard@wsu.edu, or Juming Tang; jtang@wsu.edu.
Advanced engine-control system reduces biodiesel fuel consumption and emissions

In Brief: Researchers from Purdue University and Cummins, Inc., have developed an advanced “closed-loop control” approach for preventing diesel engines from emitting greater amounts of smog-causing nitrogen oxides when running on biodiesel fuels.

Operating truck engines on a blend of biodiesel and ordinary diesel fuel dramatically reduces the emission of particulate matter, or soot. However, the most modern and efficient diesel engines burning biodiesel emit up to 40 percent more nitrogen oxides at some operating conditions, and fuel economy declines by as much as 20 percent.

Unlike conventional diesel, biodiesel contains oxygen, and researchers have shown that this presence of oxygen is responsible for the majority of the higher emission of nitrogen oxides, said Gregory Shaver, an assistant professor of mechanical engineering at Purdue.

Another key factor is a recent innovation called exhaust gas recirculation (EGR), which reroutes exhaust back into the cylinders to reduce emissions. The researchers found that nitrogen oxide emissions rise by a higher percentage in engines equipped with EGR technology compared with older engines that do not have it. However, the newer engines still emit less nitrogen oxides than the older engines.

The research addresses the need to reduce nitrogen oxide emissions and fuel consumption. Researchers used a Cummins 6.7 L, six-cylinder diesel engine, a popular power plant found in Dodge Ram pickup trucks.

“We were able to improve the fuel economy with a biodiesel blend while reducing nitrogen oxides to where they were with conventional diesel,” Shaver said. “At the same time, we were able to maintain the customary biodiesel reductions in particulate matter emissions compared to ordinary diesel fuel while not increasing noise emissions.”

Fuel economy still is problematic, however, because biodiesel has 10 to 12 percent lower “energy density,” or the amount of energy liberated during combustion, compared to regular diesel fuel, he said.

“This means you get lower mileage for biodiesel compared to ordinary diesel fuel,” Shaver said. “We improved the combustion efficiency and were able to get better mileage than before, but still not as good as conventional diesel fuel.”

The researchers developed a physics-based, closed-loop control technique, which means the system uses advanced models to self-adjust engine settings based on feedback from sensors. Software algorithms use data from the sensors to determine the fuel blend being combusted. If the fuel is changed, the system identifies the new fuel and makes critical adjustments to fuel-injection timing, the air-to-fuel ratio, and how much exhaust is rerouted into the cylinders.

“You need to be able to estimate what the blend ratio is so you know what’s going on in the engine,” Shaver said. “Is it 20 percent biodiesel fuel mixed with 80 percent regular fuel? Then we can do something to reduce the nitrogen oxides to levels consistent with a conventional fuel that did not have oxygen in it.”

Most late-model cars and trucks are already equipped with both oxygen sensors in their exhaust systems and sophisticated electronic control modules, making the technique applicable for both current and future vehicles.

“It just adds another wrinkle or two of extra intelligence to an engine’s electronic control module,” Shaver said.

The researchers extensively tested and simulated four blend ratios of biodiesel, focusing on soy-based fuel, the most commonly used biodiesel in the United States. The approach could also be used for other types of fuels and engines, including advanced lean-burn gasoline engines running on ethanol-gasoline blends.

Purdue has filed one full patent and one provisional patent related to the technique. The engine-control framework is ready for commercial use, and the researchers are working with engineers at Cummins, Inc., Shaver said.

For more information, contact Emil Venere; venere@purdue.edu.
New forest planning model could help protect stream water quality

In Brief: A new model for planning and timing of forest harvesting could help minimize the effects on water quality levels in nearby streams.

The model, which focuses on forest harvesting activities and the level of dissolved organic carbon (DOC) levels in stream water, is outlined in an article in *AMBIO: A Journal of the Human Environment*, published by the Royal Swedish Academy of Sciences.

“The strength of the model is that it is simple to use and it could be included in traditional forest planning models,” write Karin Öhman, Jan Seibert, and Hjalmar Laudon in “An approach for including consideration of stream water dissolved organic carbon in long-term forest planning.”

For the study, the three researchers developed and evaluated a model that accounted for the downstream DOC concentrations produced from cumulative forest clear-cuts over time in a watershed. Their research—among the first studies of its kind—examined a watershed in northern Sweden, where forestry is a vital part of the economy.

“Our hypothesis was that by optimizing the distribution and timing of forest harvesting activities over a rotation period in a large catchment, the combined downstream effect in sensitive stream locations could be minimized,” say the researchers. Their model allows users to specify a maximum DOC concentration increase for any location along the stream. “As a result, habitats sensitive to increased DOC levels can be protected while forestry activity continues. The model also could be used to monitor other water quality parameters.”

When DOC is not considered during forest planning, the researchers say, streams could become unsuitable habitats for many species, including brown trout. They also say the study shows that the costs involved with DOC considerations have little effect on total harvest volumes.

The model could help analysts balance timber production with the effects of forestry on water quality, the researchers say, and could provide an alternative to legislative restrictions regarding harvesting. It also shows promise as a long-term planning tool for forest managers.

“The results from the case study further indicate that with a more even distribution of harvests over time, the variation in DOC concentration over time will also decrease,” said the researchers.

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Not only is this the Last Word about why you should become a Professional Engineer (PE), but this article will also tell you about the new test specification, the myriad of resources available to help you study, and an opportunity for you to take the Agricultural Engineering (AE) PE examination for free. That’s right, for free.

Here’s why you should become an AE PE

Personally, I take great pride in being a licensed Professional Agricultural Engineer. As a university professor, I wasn’t required to be licensed, but I felt that I should be an example to my students and show that I am qualified to teach engineers as well as practice outside of the university. Every semester, I tell my students that I am prouder of my PE than I am of my PhD because, while the PhD certainly required hard work and tenacity, the PE says that I’m professionally recognized. It proves that I can both teach it and DO it. In fact, for the last seven years, I’ve been involved in preparing and assembling the AE PE exam. That has been a challenge, but I’ve found it rewarding because it’s been a great way to give something back to my profession.

That experience has also allowed me to uncover some common myths about the AE PE exam that need to be debunked. Here they are:

“The AE PE exam is too broad”

The test specification for the AE PE exam is revised every six or seven years to adjust to changes in practice. ASABE just completed an extensive survey of practicing PEs to establish a new test specification. The new specification is actually narrower than the previous specification, which should make it easier to prepare. The exam has a total of 80 multiple-choice questions in the major categories (for more detail go to: www.nces.org/Exams/PE_exam.php):

- Engineering principles and professional practice (16 questions)
- Facility engineering: Plant, animal, and commodity environments and structures (12 questions)
- Machine systems: Power, electrical/electronics, machines, controls, and sensors (20 questions)
- Natural resource engineering: Soil, water, and plant systems (24 questions)
- Process engineering: Food, feed, fiber, and fuel products (8 questions).

“The AE PE exam is harder than other PE exams”

First of all, there is some confusion over what it takes to pass the exam. The PE exam is developed to test for minimal competence, not excellence. The actual score required to pass changes from year to year, and it’s adjusted based on the exam difficulty. A good target to shoot for is to nail the questions in the Engineering Principles and Professional Practice category and your category of expertise (e.g. Natural Resources Engineering), and then try to confidently answer at least 25 percent of the questions in each of the remaining categories. The AE PE exam has passing rates comparable to other PE exams, with 70 percent to 80 percent of first-time takers passing. Exams in other disciplines are just as broad and likely include topics that practicing agricultural and biological engineers may not have experienced.

“My degree is in biological engineering. Should I take the AE PE exam?”

Absolutely! Just remember that agricultural engineering is a unique and special discipline within the broad field of biological engineering, which also includes biomedical, biomolecular, ecological, environmental, biochemical, and bioprocess engineering. Agricultural engineering is the discipline for those who are charged with coordinating plant and animal production for the world in the years ahead. Agricultural engineering operates at the interface of civil, mechanical, and electrical engineering, with additional basic knowledge of plants and animals as applied for food, feed, fiber, and fuel production. Agricultural engineering is essential, and just don’t take my word for it: in 2008, agricultural engineering was ranked No. 1 by CareerBuilder.com in its Top 10 Engineering Jobs.
“There aren’t enough study resources in AE”

There are more resources available than you may realize. A summary of the resources can be found at www.bae.ncsu.edu/www3/pe/. One of the most helpful resources is the webinar series. This series contains review sessions in which you can participate live or watch later. Past participants have found these sessions to be very helpful. The site also has a list of references, including all the books used in preparing the exam. ASABE also offers study resources that you will find helpful. A set of sample exam questions is being developed and will be available on the ASABE website (www.asabe.org) by May 31.

“Why take the AE PE instead of the CE or ME?”

Because of professional pride, to put it plainly. Every graduate from an ABET-accredited agricultural engineering, or similarly named, program with the minimum experience should take the AE PE exam. It’s a way of standing up for our discipline. To take the exam in another discipline only propagates ignorance about what agricultural engineers can really do. As a trained agricultural engineer, you already have basic knowledge and experience in several of the exam areas. With a little studying, you should be able to master a few more areas competent enough to pass the exam.

Here’s the deal: Take the AE PE exam for free!

To help overcome the limited availability of licensed Professional Engineers in our field and to encourage others in closely related disciplines within biological engineering to become part of our profession, ASABE, partnering with PEI, is offering to reimburse the AE PE exam application/test fee (up to $300) for up to 25 first-time takers for October 2010. This offer to reimburse the application/test fee is for a limited time and is available only to ASABE members. Potential examinees should grab this offer while they can. Watch the ASABE website (www.asabe.org) for further details on how to sign up.

Every engineer should strive to become a PE as a professional goal. As an agricultural engineer, passing the AE PE exam will further your career, and it will show the world that you are a qualified professional. In addition, taking the AE PE exam now will help ASABE sustain this exam for the next generation of agricultural engineers. Now is the time to step up, and it won’t cost you a dime. That’s an offer you can’t refuse!

ASABE member Jay D. Harmon is professor and extension livestock housing specialist, Department of Agricultural and Biosystems Engineering, Iowa State University, Ames, USA; jharmon@iastate.edu.

Sample AE PE question and solution

A flood control reservoir is being designed for a 40 square mile watershed. The average annual soil loss is 8 tons/acre. The design includes flood storage of 350 acre-feet, sediment storage of 127 acre-feet, and permanent pool storage of 300 acre-feet. The sediment delivery ratio is expected to be 17% with an average density of 127 lbs/cubic foot. The life of the reservoir based on sediment capacity is most nearly:

A. 10 years  B. 25 years  C. 35 years  D. 50 years

Solution

• 40 square miles × 640 acres/sq mile × 8 tons/acre/year × 0.17 delivery ratio × 2000 lbs/ton × (1 acre/43560 ft²) × (1/127 lbs/ft³) = 12.6 acre-feet per year.

• Planned sediment capacity is 127 acre-feet, so: 127 acre-feet / 12.6 acre-feet/year = 10.1 years. Therefore, answer A is most nearly correct.

This problem addresses the concept that sediment (soil) will erode from a watershed and fill a flood control reservoir, making the reservoir ineffective for flood storage after a period of time. Designers plan for a certain life for such structures by including sediment storage at the lowest elevations of the reservoir so that the impoundment can provide flood control for many years before sediment blocks the outflow structure. “Flood storage” is the capacity allowed in the event that a large storm needs to be held to avoid downstream damage to property. “Permanent pool storage” is the volume of water to be held in the reservoir most of the time, perhaps providing a lake for recreational activities. “Sediment storage” is the capacity that is designed to be filled by sediment over the reservoir’s life.
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