Focus on Air Quality

Biosensor Detection of an Airborne Mystery Disease

Regulating PM Emissions from Agricultural Operations

Agricultural Odors

The EPA Non-road Diesel Tier 4 Final Rule

PUBLISHED BY ASABE – AMERICAN SOCIETY OF AGRICULTURAL AND BIOLOGICAL ENGINEERS
Food, Feed, Fiber, and Furries

We had a very successful annual meeting in Pittsburgh last June. According to the final tally, there were 1,418 attendees with 487 students. It was especially good to see such a large student attendance. These bright young members are our future, and the future is clearly in good hands. We also hosted more than 150 technical sessions. If you were not able to be there this year, you missed an excellent, informative meeting. Start planning now for next year’s meeting, August 7-10, in Louisville, Ky. Did you catch that? August, not June. Next year’s meeting is a little later than usual.

As our annual meeting was winding down on Wednesday and Thursday, another convention, called Anthrocon 2010, was coming to town. Anthrocon is an official event of the “furries,” that is, people who like to dress up as cats, dogs, and other furry creatures. You might be wondering why I’m mentioning this. At the very least, the furries put on an interesting and unusual event. But more importantly, if you can believe what they told us, their attendance was expected to be 4,500! Think of that: 4,500 people coming together from all over the country, and from other countries, just to dress up and act like animals. At our annual meeting, we can assemble only a third as many to discuss the advancement of engineering in agricultural, food, and biological systems. What are we doing wrong? Maybe we should require costumes, too.

As the ASABE web site says, “Biological and agricultural engineers ensure that we have the necessities of life: safe and plentiful food to eat; pure water to drink; clean fuel and energy sources; and a safe, healthy environment in which to live. More specifically, biological and agricultural engineering is the application of engineering principles to any process associated with producing agriculturally based goods and management of our natural resources.” Now you be the judge. Which meeting do you think should attract the higher attendance: people in furry suits with big floppy ears, or the engineers whose work has given us the quality of life, and the leisure time, to indulge ourselves in events like Anthrocon?

As a side note, it’s rumored that one of our past presidents recruited one of the Anthrocon members, meeting my challenge to each ASABE member to recruit “Just One” more member. I hope to meet that new member next year in Louisville. In the meantime, how are you coming with your recruit?

Ronald L. McAllister
ron.mcallister@cnh.com

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

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<td>Sept. 13-16</td>
<td>International Symposium on Air Quality and Manure Management for Agriculture.</td>
<td>Dallas, Texas, USA.</td>
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<td>Nov. 14-17</td>
<td>TMDL 2010: Watershed Management to Improve Water Quality.</td>
<td>Baltimore, Maryland, USA.</td>
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<td>Dec. 5-8</td>
<td>5th National Decennial Irrigation Conference.</td>
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2011

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<td>Agricultural Equipment Technology Conference.</td>
<td>Held in conjunction with AgConnect Expo 2011. Atlanta, Georgia, USA.</td>
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<td>Aug. 7-10</td>
<td>ASABE Annual International Meeting.</td>
<td>Louisville, Kentucky, USA.</td>
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<td>Sept. 18-22</td>
<td>International Symposium on Erosion and Landscape Evolution Conference.</td>
<td>Joint conference with with AEG. Anchorage, Alaska, USA.</td>
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ASABE ENDORSED EVENTS

2010

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<tr>
<td>Sept. 16-20</td>
<td>International Agricultural Engineering Conference.</td>
<td>Shanghai, China.</td>
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2011

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<td>March 14-16</td>
<td>BioPro Expo.</td>
<td>Atlanta, Georgia, USA.</td>
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<tr>
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Air Quality Issues Related to Agricultural Operations

Air quality has been an important issue for many years due to health and quality of life concerns. Regulations for controlling emissions of constituents into the air have become increasingly stringent, and many areas of agriculture have been impacted as we try to meet these regulations. Even in areas where there are no direct regulations, we are seeing impacts due to court judgments and public perceptions.

Agricultural sources of gases and particles that may get into the air include engines, field operations, agricultural burning, animal operations, chemical application, and processing/handling facilities. Engineers and scientists are working to address many air quality issues related to agricultural operations, and in this special issue of *Resource*, we discuss a few of the concerns.

Biological materials in the air are an increasing concern. These may include microorganisms, disease, allergens, feces, and many other materials that cause a negative response in humans, plants, or animals. The article related to biosensors gives a good example of how biosensors are being developed for detecting disease organisms and how disease transfer in the environment is being tracked.

Emissions of odorous compounds into the air, particularly from animal operations, have led to many conflicts with neighbors and regulators. Odor is a very complex issue as it involves human perception and response and not just direct measurements of compounds in the air. The human nose is very sensitive to certain compounds, and once these compounds get mixed into the air, they are difficult to remove.

The feature on agriculture odors discusses the many challenges of addressing odor problems.

EPA’s Tier 4 rule has kept engineers busy in recent years as the reduced exhaust emission regulations for non-road diesel engines are being phased in. The new rules are very stringent and have challenged engineers to develop engines to meet the reduced emissions in a cost-effective manner. The related article gives some background on the regulations and explains how some industry engineers are planning to meet the rules.

Particulate matter has been a major concern, especially for material processing and animal operations. These agricultural operations are economically and technically challenged to comply with the increasingly stringent air pollution regulatory demands related to permitting, enforcement, and compliance with the federal Clean Air Act. In many cases, obtaining accurate emission rates is extremely difficult due to the many factors involved and the widely dispersed sources. There are cases where regulations and monitoring techniques developed for urban situations are being applied to agriculture, which has very different circumstances. It is important to develop appropriate emission measurement and prediction methodologies to ensure fair regulation of agricultural operations, and the related feature on regulating PM emissions summarizes the challenges involved.

Air quality is important to all of us, and I hope this special issue of *Resource* helps you to understand how ASABE engineers are working hard to address emissions from agricultural operations.

ASABE fellow Gerald Riskowski is a professor and head, Department of Biological and Agricultural Engineering, Texas A&M University, College Station, USA, and serves as guest editor of this special issue of *Resource*; riskowski@tamu.edu.
Biosensor Detection of an Airborne Mystery Disease

Jeong-Yeol Yoon and Hyuck-Jin Kwon

Porcine reproductive and respiratory syndrome (PRRS) is one of the most economically important diseases for the swine industry. PRRS is caused by the PRRS virus (PRRSV), which was simultaneously isolated in Europe and the United States in 1991. PRRSV infection causes reproductive failure and pneumonia in pigs, and it had been widely considered to be a “mystery” disease among swine herds before the virus was isolated.

PRRSV can spread through the air, due to pigs’ respiration or coughing, but it does not affect humans. Therefore, PRRSV can serve as a perfect surrogate for swine influenza A (especially the 2009 H1N1 influenza A) for developing a rapid monitoring system for the spread of influenza in human environments.

The use of a near-real-time, field-deployable biosensor device in a networked system in a real animal/human environment is the key to monitoring the spread of dangerous viral pathogens. Surrogate molecules have been used to perform experimental monitoring and/or CFD studies, including smoke (for particulate movement) and CO₂ (to simulate respiration). However, up until now, the spread of PRRSV (and other airborne viral pathogens) in air has not been investigated in-depth using a network of real-time biosensors or computational fluid dynamics (CFD) studies.

The current gold standard for detecting both PRRSV and influenza A is reverse transcription polymerase chain reaction (RT-PCR), which may take up to four hours to perform, including sample pre-processing, reverse transcription, thermocycling, and gel imaging for product identification. The process also requires laboratory space, which creates an additional time lag for sample delivery.

We may be able to resolve these issues by using a “lab-on-a-chip” (LOC) to monitor this type of airborne pathogen. An LOC is essentially a network of channels and wells that...
are etched onto glass or polymer chips to build a miniaturized laboratory. Using a technique called “microfluidics,” pressure or electrokinetic forces move small volumes in a finely controlled manner through the channels. An LOC may enable us to perform sample handling, mixing, dilution, electrophoresis, staining, and detection in a single integrated system. The main advantages of an LOC are its ease of use, speed of analysis, low sample and reagent consumption, and high reproducibility due to standardization and automation. By connecting air samplers to the LOC device, we may be able to create an antibody-based LOC sensor system that detects airborne pathogens in near-real-time (<5 min), just like a smoke detector.

Detections in LOCs have largely been made electrochemically (amperometry, conductometry, etc.) due to the ease of integration of these processes into an LOC. In recent years, however, optical detectors have become more popular in LOCs due to their excellent sensitivity. In fact, with optical detection, it may be possible to detect targets at the single-cell or single-virus-particle level. The main challenge of optical detection in an LOC is how we can guide light to travel in a finely controlled manner (called “optofluidics”).

Our research team at the University of Arizona is currently working on an LOC device for particle immunoassays that utilizes both microfluidics and optofluidics. We recently demonstrated the use of a liquid-core waveguide (an optofluidics process) to detect PRRSV on nasal swabs from pigs and in specimens from air samplers within a swine building, and the results were compared with those of standard RT-PCR assays. The liquid-core optical waveguide has also been investigated to substitute “embedded” optical fibers, in which the liquid channel acts as core and the surrounding polymer substrate (e.g., polydimethyl siloxane or PDMS) acts as cladding. Liquid-core waveguide chips have not been previously investigated for light scattering detection of particle immunoassays, although the technology is a good fit for this application. The use of liquid-core waveguide channels would greatly enhance the reproducibility of the signals due to their fixed alignment, as compared to our previous attempts using a “proximity” setup of optical fibers.

A three-dimensional computational fluid dynamics (CFD) simulation has also been attempted to track the transport and distribution of PRRSV within a swine building (from the mouths of pigs to the exhaust fans), and compared
with the readings from an optofluidic device. Three-dimensional CFD studies that simulate respiratory behavior of animals in a confined environment are relatively rare, although similar studies of plants can occasionally be found. However, three-dimensional CFD studies of airborne pathogens with experimental validations are extremely rare. This systematic investigation will allow us to determine how many sensors need to be installed in a swine building, and in what locations, to reliably monitor airborne pathogens.

The developed optofluidic device will ultimately be tested for detecting swine influenza A subtype H1N1. Our group has already succeeded in detecting 2009 H1N1 influenza A with this device with a lower limit of detection (LOD) of 1 pg/mL (typical LODs of virus antigens are greater than a few ng/mL). The spread of H1N1 flu can also be monitored experimentally using a miniature model of a human environment, such as a classroom. In this study, solutions of empty H1N1 flu capsids were sprayed into the structure, and two-dimensional CFD simulations were conducted to track the transport and distribution of H1N1 flu in the miniaturized classroom. The developed optofluidic device and the three-dimensional CFD model would serve as a good model for monitoring the spread of many other viral pathogens within animal and human environments, especially for avian and swine influenza that affects both animals and humans.

**ASABE member Jeong-Yeol Yoon** is an associate professor and **Hyuck-Jin Kwon** is a graduate student in the Department of Agricultural and Biosystems Engineering, University of Arizona, Tucson, USA; jyyoon@email.arizona.edu.
Many people dream of country living with its open spaces, clean fresh air, and smells of grasslands, forests, and freshly mown hay. But occasionally the dream is shattered by unpleasant odors from animal feeding operations, food and ethanol processing plants, or other agricultural activities. To meet community expectations, owners and managers need to manage unpleasant odors.

**Odor basics**

Most odors are comprised of hundreds of volatile compounds, some of which are detected at concentrations as low as parts per trillion. While some people are hypersensitive to odors, others have a poor sense of smell. The complex mixtures that make an odor and the varied reactions complicate odor management.

Odors can evoke strong emotions and stimulate physiological responses. The perfume, personal products, and cleaning industries sell products with odors that people enjoy, that make them feel good, or that give them a sense of cleanliness and freshness. Aromatherapy products give off aromas that are relaxing or stimulating. Unpleasant odors can provoke strong responses, too.

Odors are described in terms of concentration, intensity, persistence, hedonic tone (i.e. pleasantness or unpleasantness), and character descriptors. When managing agricultural odors, it is common to focus on odor frequency, intensity, duration, and offensiveness (FIDO). Odor frequency describes how often, in a month, offensive odors are detected. Intensity is the odor strength, which is analogous to the loudness of a noise. Duration describes how long an odor event is detected, and offensiveness describes how unpleasant the odor is.

Odors can be managed by keeping the concentrations at non-offensive levels most of the time (90 to 98 per cent of the time). Many agricultural communities and units of government recognize that totally eliminating agricultural odors is not economical, so they strive to develop community expectations and regulations that allow offensive odors for limited amounts of time. Mitigation practices may be required if odor sources are expected to emit odors that will exceed community expectations. The setting of community odor expectations is a political process.

**Odor measurement**

Odors are difficult to measure and describe in a repeatable scientific way. Most techniques rely on people trained to assess odor presence and intensity. There are laboratory devices, handheld devices, and people trained to measure odor intensity in the field. Care must be taken to prevent odor fatigue of the human olfactometry system, which is when a person no longer detects an odor after an intense odor experience or a long period of exposure to odorous air.
There are devices to measure chemical concentrations in the air, but there is no established relationship between chemical concentration and agricultural odor. Over 300 gases and vapors have been reported to have come from livestock manures. Research continues to develop a usable relationship between chemical concentration and agricultural odor and devices to measure odor.

Managing agricultural odors

Good neighbor relations and communications can help agricultural business owners be aware of odor issues. Being open to neighbor input about odor problems and letting neighbors know what is being done to mitigate odors helps establish effective communications. It is commonly recommended that people planning to build a new animal feeding operation or expand an existing one visit with neighbors to let them know what is being planned, including why and how odors will be managed.

Agricultural odors are generated, emitted, and transported from a source to a receptor. Receptor sites include property lines, neighbors’ houses, and nearby public areas, including public roads, schools, parks, and towns.

Key odor sources on animal feeding operations include barns, open lots, manure treatment and storage units, and fields where stored or fresh manure is land applied. Ventilation exhausts and emissions from food processing and ethanol plants can emit odors, too.

Odors can be managed by reducing source generation or emission, capturing and treating odorous air, or by increasing dispersion. The goal of odor management is to reduce odor concentrations to non-offensive levels most of the time at receptor sites.

Several states use tools for assessing the potential odor impact of animal feeding operations. The tools consider feedlot size, production practices, and local weather conditions that impact odor dispersion. The tools are typically used to compare alternative feedlot sites and the need for odor mitigation to meet local community odor guidelines.

Odor mitigation

Odor mitigation practices are an active area of research and development. One or more practices can be used. Mitigation practices used need to be effective, economical, and fit into the operation.

Animal diet and feed management are used to provide all of the essential nutrients and energy needed for optimum production while minimizing the nutrient emissions in feces and urine, enteric emissions, and subsequent emissions from stored and land-applied manure.

Chemical and biological additives are used to reduce odor generation or emissions during manure transport, storage, agitation, and land application. Chemicals can be added to oxidize odorous volatile compounds, adjust pH, or react with volatile compounds and form precipitates. Biological additives attempt to change the biochemical pathways that produce odorous gases.

Covers on manure storage reduce odor emissions by creating a barrier between the stored manure and the airflow above it. Covers can be either permeable or impermeable. Permeable covers allow gas molecules and water to pass through, while impermeable covers trap most gas molecules between the cover and the manure. Impermeable covers can cut emissions by nearly 100 per cent.

Gas-phase biofilters can treat ventilation air or air from manure storage units. Biofilters absorb noxious gases into a biofilm where microorganisms break down the gases and use the energy and nutrients to grow and reproduce. Well designed and managed biofilters can reduce odors and hydrogen sulfide by as much as 95 percent and ammonia by 80 percent.

Enhanced dispersion mixes odorous gases in the air to reduce their concentrations to below detection levels. Dispersion is enhanced using vegetative buffers, wind walls, chimneys, and increased separation distances between odor sources and neighbors, towns, schools, parks, and other public areas.

The bottom line

Advances in agricultural odor awareness, research, and development have expanded our capabilities to assess and manage unpleasant smells, but many questions and challenges remain. In the meantime, people will continue to dream of country living, with its open spaces, verdant landscapes, and occasional odors.

*ASABE member Kevin Janni* is a professor and extension engineer, Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, USA; kjanni@umn.edu.
The EPA Non-road Diesel Tier 4 Final Rule
An Overview

As you may have heard, the U.S. Environmental Protection Agency (EPA) is adopting a comprehensive national program to reduce emissions from future non-road diesel engines by integrating engine and fuel controls as a system. To meet these new emission standards, engine manufacturers will produce non-road engines with advanced emission-control technologies similar to those already required for highway trucks and buses. As a result, exhaust emissions from these new engines will decrease by more than 90 percent. In addition, because the emission-control devices can be damaged by sulfur, the EPA is also adopting a limit that will decrease the allowable level of sulfur in non-road diesel fuel by more than 99 percent.

These reductions in NOx and PM emissions from non-road diesel engines will provide extensive public health benefits, and the rule includes provisions to help ensure that the emission-control systems perform as well in actual use as they do in the laboratory.

This new rule sets specific emission standards for different sizes of non-road engines, as summarized in the table below. To provide adequate lead time to engine and equipment manufacturers, the standards will be phased-in over several years. The standards took effect for new engines beginning in 2008, and they will be fully phased in for most engines by 2014. Larger mobile engines (greater than 750 horsepower) have one year of additional flexibility to meet their emission standards.

These emission standards apply to the diesel engines that are used in most construction, agricultural, industrial, and airport equipment. They are similar in stringency to the standards adopted for 2007 and later diesel-powered trucks and buses. The EPA has historically tightened non-road engine regulations after setting more stringent standards for on-road engines. In this case, the non-road Tier 4 program follows the EPA’s heavy-duty truck 2007/10 standards.

Reduced sulfur levels

Just as lead was phased out of gasoline to prevent damage to catalytic converters, decreasing the sulfur levels in non-road diesel fuel will prevent damage to the emission-control systems in diesel engines. In addition, reducing sulfur levels provides immediate public health benefits by reducing particulate matter emissions from the existing fleet of non-road equipment, while reducing engine maintenance costs. When fully implemented, this rule will reduce current sulfur levels from about 3,000 parts per million (ppm) to 15 ppm, a reduction of greater than 99 percent.

The rule reduces non-road diesel fuel sulfur levels in two steps. First, beginning in 2007, fuel sulfur levels in non-road diesel fuel were limited to a maximum of 500 ppm, the same as for current highway diesel fuel. This limit also applies to fuels used in locomotive and marine applications (although not to the marine residual fuel used by very large engines on ocean-going vessels).

Second, starting this year, sulfur levels in most non-road diesel fuel must be reduced to 15 ppm. This ultra-low sulfur fuel creates an immediate public health benefit and makes it possible for engine manufacturers to install the advanced emission-control systems that will dramatically reduce both PM and NOx emissions. In the case of locomotive and marine diesel fuel, this second step will occur in 2012.

Final Emission Standards in grams per horsepower-hour (g/hp-h):

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<th>Rated Power</th>
<th>First Year that Standards Apply</th>
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<th>NOx</th>
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<tr>
<td>hp &lt; 25</td>
<td>2008</td>
<td>0.30</td>
<td>–</td>
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<tr>
<td>25 ≤ hp &lt; 75</td>
<td>2013</td>
<td>0.02</td>
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<tr>
<td>75 ≤ hp &lt; 175</td>
<td>2012-2013</td>
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<tr>
<td>175 ≤ hp &lt; 750</td>
<td>2011-2013</td>
<td>0.01</td>
<td>0.30</td>
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<tr>
<td>hp ≥ 750</td>
<td>2011-2014</td>
<td>0.075</td>
<td>2.6/0.50†</td>
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</tbody>
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* The 3.5 g/hp-h standard includes both NOx and non-methane hydrocarbons.
† The 0.50 g/hp-h standard applies to gensets over 1200 hp.
** The 0.02 g/hp-h standard applies to gensets; the 0.03 g/hp-h standard applies to other engines.
†† Applies to all gensets only.
Estimated costs
The cost of producing 15 ppm sulfur for this program is expected to total seven cents per gallon. However, because the use of ultra-low-sulfur fuel will significantly reduce engine maintenance expenses, the EPA estimates that the net cost will average about four cents per gallon.

The estimated costs for a non-road equipment manufacturer to comply with this program will vary depending on the size and complexity of the equipment. As an example, the EPA estimates that for a typical 175 horsepower bulldozer, the modifications will cost approximately $2,600, compared to the overall price of approximately $240,000 for such a machine. Similarly, the anticipated costs for most categories of non-road diesel equipment are in the range of 1 to 3 percent of the total purchase price.

To reduce the economic impact of meeting the new emission standards and the requirements for low-sulfur fuels, the final rule includes a number of flexibility provisions that are primarily aimed at helping small engine manufacturers and refiners meet the requirements.

Benefits of the program
Reducing NOx and PM emissions from non-road diesel engines by more than 90 percent provides a wide range of public health benefits. The EPA estimates that, by 2030, controlling these emissions will annually prevent 12,000 premature deaths, 8,900 hospitalizations, one million work days lost, 15,000 heart attacks, 6,000 children’s asthma-related emergency room visits, 280,000 cases of respiratory problems in children, 200,000 cases of asthma symptoms in children, and 5.8 million days of restricted adult activity due to respiratory symptoms.

In addition, the EPA estimates that the health benefits of this rule, in dollars, will be $80 billion a year, once all older engines have been replaced. Estimated costs for the engine and fuel requirements are many times less, amounting to about $2 billion annually in the same time frame. In other words, the cost-benefit ratio of this program will be approximately 40 to 1.

In light of these requirements, and the anticipated benefits, Resource asked three major agricultural equipment manufacturers (John Deere, AGCO, and CNH) what steps they were taking to comply with the EPA’s Tier 4 final rule. Their answers follow.

John Deere and Tier 4
For 75 horsepower and larger engines, John Deere will start with its PowerTech Plus engine platform, which includes cooled exhaust gas recirculation (EGR) for NOx control, and add an exhaust filter for reducing particulates. The exhaust filter consists of a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF) designed to meet the demands of non-road applications. The DOC reduces carbon monoxide, hydrocarbons, and particulates, while the downstream DPF traps and holds particulates remaining in the exhaust stream. Trapped particles are eventually oxidized within the DPF through a regeneration process. Under normal circumstances, the regeneration process will not affect machine operation and will not be noticeable by the operator. The exhaust filter also eliminates the need for an engine muffler in most applications.

To meet Tier 4 requirements, the engine’s cylinder head, fuel system, EGR system, VGT system, and air-to-air aftercooling system will be updated but will be similar to the existing Tier 3 configurations. In other words, John Deere’s Tier 4 engines, with cooled EGR and an exhaust filter, will require the same space as the Tier 3 engine and muffler that they replace. Engine-mounted or remote-mounted exhaust filters for 4.5 L and 6.8 L models below 174 horsepower will be available for increased flexibility.

In choosing a solution for interim Tier 4 compliance, John Deere has elected not to use SCR. An SCR system injects liquid urea into the exhaust stream to reduce NOx. While effective, this technology requires that the vehicle be fitted with a separate tank, a sophisticated urea injection system, and a tamper-proof diagnostic system, which is required by regulation. Because urea freezes, heating systems for the tank and delivery lines are also necessary. In addition, urea is not conveniently available in many parts of the world, especially for non-road applications, which creates availability and storage concerns.
Most importantly, John Deere’s cooled EGR solution does not require operator intervention. The operator doesn’t have to deal with a second fluid and doesn’t have to go through training on the SCR system. SCR may be an appropriate technology for the future, when the technology is more developed for non-road applications. However, for interim Tier 4 compliance, John Deere’s cooled EGR and exhaust filter technology provides a proven solution with the best value product.

For more information, contact Kevin Price, Engine Engineering—John Deere Power Systems, PriceKevinA@JohnDeere.com.

AGCO e3 Selective Catalytic Reduction Clean Air Technology

AGCO chose SCR (selective catalytic reduction) as the platform it will use for meeting the EPA’s Tier 4 emission standards for non-road diesel engines. SCR exhaust gas after-treatment was originally used to reduce NOx emissions from coal-fired power plants, and it has been widely used in the trucking industry. AGCO’s brand of SCR technology, called e3, is designed to lower emissions of nitrogen oxide (NOx) and particulate matter (PM) in the exhaust gases of diesel engines.

AGCO chose this post-combustion process as the most farmer-friendly and most effective approach to EPA compliance. Because SCR takes place within the exhaust system, it does not interfere with the engine’s ability to create power and torque. In addition, the technology is simple, robust, and reliable. The main components are a tank, an injection system, and a catalytic chamber (diagram at right).

With the e3 system, an NOx reducing agent called diesel exhaust fluid (DEF) is injected into the exhaust gas upstream of the e3 catalyst chamber. DEF is a non-hazardous, high-purity, colorless solution containing 32.5 percent urea plus deionized water. When heated, DEF becomes ammonia and reacts with NOx in the exhaust to convert pollutants into nitrogen, water vapor, and tiny amounts of CO2. The DEF is carried in a separate tank on the tractor and is consumed at a rate of about 3 percent DEF/diesel.

The e3 technology can achieve NOx reductions in excess of 90 percent, and the system also provides improved combustion, which reduces particulate emissions (PM) to 70 percent below current standards. Because SCR optimizes combustion, which in turn lowers heat rejection (wasted energy) by 15 percent, the cooling package for the engine can be smaller. The technology adds nothing to the cost of the tractor and even eliminates the need for expensive add-ons like ECEGR packages and large coolers.

Emission control technologies often decrease fuel efficiency. However, test results from the University of Nebraska Tractor Test Laboratory have shown that AGCO’s 205 to 275 PTO horsepower rowcrop tractors, powered by the AGCO SISU POWER™ 8.4 L engine with e3 technology, delivered fuel efficiency that was 4 percent to as much as 17 percent better than other tractors in this category.

For more information contact Jason Houl, AGCO Marketing Manager, High Horsepower Rowcrop Tractors, jason.houl@AGCOcorp.com, or Dee Weeda, Broadhead + Co., dweeda@broadheadco.com.
CNH Tier 4 Emissions: Two Solutions, No Compromises

CNH agricultural equipment features two technologies to meet the Tier 4 emissions standards without compromising engine performance: selective catalytic reduction (SCR) for medium- and heavy-duty engines, and cooled exhaust gas recirculation (CEGR) for light-duty engines (less than 100 horsepower).

The CEGR system is ideal for low-horsepower engines based on usage requirements, engine compartment limitations, and overall cost of ownership. SCR technology is the best solution for high-horsepower diesel engines because it offers more horsepower and torque, with better fuel economy. As part of the Fiat Group, CNH sources engines from Fiat Powertrain Technologies (FPT). FPT-powered trucks have logged more than 20 million miles using this technology.

Because an SCR system is separate from the engine, it does not interfere with engine operation. This post-combustion process offers several advantages:

- More power – Because exhaust is treated post-combustion, all available engine displacement is used for making horsepower.
- Better fuel economy – The engine uses less fuel in high-horsepower applications because the engine timing is optimized for economy and not limited for NOx control.
- Less heat – SCR aftertreatment systems are passive, so no extra heat is required for periodic regeneration, allowing the SCR system to run cooler.
- Simple service – The engine oil maintains its physical properties, so there is no increase in maintenance, and the SCR substrate is designed for the life of the engine.

FPT’s SCR technology reduces particulate matter (PM) by 90 percent by running the engine at optimum performance. In addition, it reduces nitrogen oxide (NOx) by 50 percent by injecting diesel exhaust fluid (DEF) into the exhaust stream. The DEF converts nitrogen oxide into harmless water vapor and nitrogen vapor that is released through the exhaust stream. The SCR system components include a DEF tank, a DEF supply module to move the DEF from the tank to the injector, an injector that meters DEF into the exhaust system, an SCR chamber where DEF mixes with exhaust gas and reacts, and a NOx sensor to measure the levels of NOx leaving the SCR chamber.

With an SCR system, the engine can still run on all diesel fuel varieties and grades, including up to 100 percent biodiesel. Most industry engineers agree that SCR systems are the only way to meet 2014 Tier 4B standards, so CNH and FPT are committed to developing this technology.

For more information, contact Richard Heisey, richard.heisey@cnh.com.
Emission rates of particulate matter (PM) emitted by agricultural operations such as cattle feed yards, dairies, oil mills, cotton gins, grain elevators, and feed mills are regulated by state air pollution regulatory agencies (SAPRAs). The authority for the U.S. Environmental Protection Agency (EPA) to regulate emissions of air pollutants including PM is the federal Clean Air Act (CAA). The CAA is a compilation of numerous CAA amendments (1955, 1963, 1965, 1967, 1970, 1977, and 1990).

The objective of the air pollution regulatory process (APRP) is to limit emission rates of PM so that the public (off-property) is exposed to concentrations less than the National Ambient Air Quality Standards (NAAQS). The EPA sets the NAAQS for all criteria pollutants, including PM. The tasks associated with the APRP are permitting, dispersion modeling, and enforcement. In general, SAPRAs perform the tasks associated with the APRP, with oversight from the EPA.

Agricultural engineers have made a number of contributions that have had an impact on the regulation of PM emissions from agricultural operations. Specifically, in order to appropriately regulate PM emitted by agricultural operations, the following are required:

- Knowledge of the agricultural operation
- Accurate emission factors
- Particle size distributions of the PM emitted
- Abatement strategies
- Dispersion modeling skills.

The Center for Agricultural Air Quality Engineering and Science (CAAQES) within the Department of Biological and Agricultural Engineering at Texas A&M University has conducted research for many years addressing APRP issues. The justifications for all CAAQES research efforts have been the real or anticipated inappropriate regulatory actions by the EPA or by SAPRAs. Inappropriate actions by a regulatory agency can be costly and are usually a consequence of a lack of technical information or knowledge of the operation. CAAQES research has focused on accurate emission factors for almond orchards, cotton gins, grain elevators, feed mills, oil mills, feed yards, dairies, cotton harvesting, and broiler operations. The following feed yard and feed mill example will illustrate how CAAQES research has impacted the regulation of agricultural PM emissions.

From 1970 until 1986, PM was regulated as total suspended particulates (TSP). Concentrations were measured using high-volume samplers. The primary NAAQS for TSP was 260 µg/m³. In 1987, the EPA replaced the TSP NAAQS with a 150 µg/m³ PM₁₀ NAAQS. The TSP emission factor listed by the EPA in AP-42 Compilation of Air Pollutant Emission Factors and used by SAPRAs to permit feed yards was 280 pounds per 1000 head per day (lb/1000hd/day). This factor was the result of research findings in the early 1970s. In addition, based on co-located TSP and PM₁₀ concentration measurements at feed yards, CAAQES faculty determined that 25 percent of the TSP emitted by a feed yard was PM₁₀. This finding was accepted by the EPA as the PM₁₀ emission factor for cattle feed yards.

Title V of the 1990 CAA amendments authorized the EPA or SAPRAs to levy fees on all major pollutant sources. A major source was defined as one that emitted more than 100 tons per year of a regulated pollutant. At the time, TSP was a regulated pollutant. The problem that the cattle feeding industry faced was that all feed yards with more than 2,000 head emitted more than 100 tons per year of PM. As a result, all feed yards in Texas were major sources and would be required to obtain a Title V permit and pay annual fees. The EPA had recommended a fee of $25 per ton. Therefore, based upon the TSP emission factor, a typical 40,000-head feed yard would pay over $51,000 per year in fees.
In 1994, CAAQES graduate students used previously measured concentration data with the EPA’s recommended area source dispersion model and reported that the PM$_{10}$ emission factor for cattle feed yards should really be 10 lb/1000hd/day. A subsequent study funded by the Texas SAPRA found that mistakes were made in the calculations of the original TSP emission factor of 280 lb/1000hd/day.

In 1999, CAAQES was funded by the TNRCC to perform additional sampling. The resulting PM$_{10}$ emission factor based on these new sampling results was 15 lb/1000hd/day.

The EPA encountered problems with the policy of including fugitive PM emissions in the summation of annual emissions to compare to the threshold of 100 tons per year for major source classification. The number of major sources was very high, and the resources required to manage this high number of Title V permits did not exist in the EPA or in SAPRAs. In 1995, the EPA published a guidance memorandum for SAPRAs, changing this policy. The new policy was that SAPRAs should only use stationary (point) source annual emissions of PM$_{10}$ at the site as the criterion for major source classification. This meant that the emissions from feed mills on cattle feed yards would be used to determine whether the feed yard was a major source. If the mill’s PM$_{10}$ emissions exceeded 100 tons per year, then the entire feed yard would be a major source and Title V fees would be levied based upon all PM$_{10}$ emissions, including the fugitive emissions from the yard.

Some states were using a PM emission factor for grain elevators and feed mills of 10 lb/ton. This emission factor, if not corrected, would have resulted in many grain elevators and feed mills classified as major sources, with the requirement to obtain Title V permits and pay Title V fees. If the feed mill on a feed yard was classified as a major source, then the feed yard would be classified as a major source as well, and all regulated PM emissions, including fugitive PM emissions, would be used to determine Title V fees. It was important that the feed mill emission factor be accurate!

In 1988, the AP-42 TSP emission factor for feed mills associated with cattle feed yards was 2.5 lb/ton for grain unloading and 1 lb/ton for feed loading. The PM$_{10}$ emission factors were calculated using an assumed 25 percent of the TSP factors. The corresponding AP-42 PM$_{10}$ emission factors for grain unloading and feed loading were therefore 0.63 and 0.25 lb/ton, respectively. In 1998, CAAQES faculty reported results of an intensive research effort to determine accurate feed mill emission factors. Data were collected at feed mills in Nebraska, Kansas, and Texas. The TSP emission factors were 0.04 lb/ton for grain unloading and 0.005 lb/ton for feed loading, and the PM$_{10}$ emission factors were 0.006 lb/ton for grain unloading and 0.002 lb/ton for feed loading. The new technical data on PM$_{10}$ emission factors for feed mills associated with cattle feed yards resulted in no feed mill or feed yards classified as major sources.
In summary, providing SAPRAs or the EPA with accurate engineering data on emission rates of TSP, PM$_{10}$, and PM$_{10-2.5}$ emitted by agricultural operations for specific control strategies is essential. The CAAQES goal is to conduct the research that will facilitate appropriate regulation of PM emitted by agricultural operations. This research is best accomplished by agricultural engineers. The challenges in the future include the following:

First, the EPA is in the process of promulgating a new NAAQS for PM$_{10-2.5}$. It is rumored that the new NAAQS for PM$_{10-2.5}$ will be 65 to 75 µg/m$^3$. It is unlikely that any agricultural operation will be able to meet the permitting requirement of 24-hour PM$_{10-2.5}$ concentrations less than 75 µg/m$^3$ at the property line and beyond. Agricultural operations emit larger PM relative to urban PM. Median sizes of PM emitted by agricultural operations typically range from 15 to 30 µm, while urban PM typically ranges from 5 to 10 µm. As a consequence, almost all of the PM emitted by an agricultural operation is PM$_{10-2.5}$. For example, an accurately measured PM$_{10}$ concentration from an agricultural source of 150 µg/m$^3$ will contain a PM$_{2.5}$ component of less than 5 µg/m$^3$ with a corresponding PM$_{10-2.5}$ component of 145 µg/m$^3$. Promulgating a coarse PM NAAQS of 70 µg/m$^3$ would require all agricultural sources to reduce their PM emission rates by more than 50 percent.

In addition, all EPA-approved federal reference method (FRM) samplers do not accurately measure PM concentrations in the presence of the large PM that is typical of PM emitted by agricultural operations. The term used for this phenomenon is “over-sampling.” For example, a 300 µg/m$^3$ PM$_{10}$ concentration measurement with an FRM sampler is in reality less than 150 µg/m$^3$, and a 50 µg/m$^3$ PM$_{2.5}$ concentration measurement with an EPA-approved FRM sampler is likely less than 10 µg/m$^3$. The use of FRM samplers to regulate emissions of PM from agricultural operations will result in inappropriate enforcement actions by SAPRAs and/or the EPA.

**ASABE Fellow Calvin B. Parnell, Jr.,** is regents professor, Department of Biological and Agricultural Engineering, and director of the Center for Agricultural Air Quality Engineering and Science (CAAQES), Texas A&M University, College Station, USA; c-parnell@tamu.edu.
I grew up in a family greenhouse operation. We grew cucumbers and tomatoes commercially, on six acres under glass, so it involved some very intense management. At some point, I did every job on the place. I learned to love agriculture and knew that it would somehow be my career. Toward that goal, I earned my BS in agricultural engineering from The Ohio State University and received an MBA from Loyola University in Chicago.

During my college years, I worked summers in the family greenhouse. After graduation, I spent a couple of years working for a scrap steel processor. Most recently, I worked for AEM, responsible for their statistics, technical, and safety programs.

Moving to Michigan is like coming full circle. I briefly lived in New Buffalo when I worked at what was then Bethlehem Steel 22 years ago. Southwest Michigan is lovely with the water and sand dunes. My family will especially enjoy it here, since we often spend part of our vacations exploring lighthouses.

What ASABE means to me

It’s simple: Agriculture is food, and food is life. Or to put it more thoroughly: Agricultural and biological engineers collectively ensure that the world has all the necessities of life, including safe and plentiful food, clean water, renewable fuel and energy, safe working conditions, and a healthy environment. This is incredibly important work, and I’m very excited to be involved with it.

As the new executive director, I now have overall responsibility for the day-to-day operation of the Society and its many activities. This includes meetings, membership, publications, and standards. In addition, ASABE has excellent liaison relationships with many other organizations, and it will be my privilege to enhance and expand these. It’s a big challenge, and I hope that it will be fun as well.

The hardest thing so far

Every job starts with a bang, and this one has been no exception. My first week on the job was our annual meeting, which went very well, and we had a wonderful fundraising dinner for the ASABE Foundation. However, some of the attendees became ill after the dinner. In addition to the inconvenience of being sick far from home, at least one person was briefly hospitalized.

Fortunately, everyone recovered, and the Allegheny County Health Department did a very thorough job investigating the incident. And the story has a happy ending: The hotel refunded our food costs, and most of the attendees generously chose to donate their share of the refund back to the Foundation. We’re very grateful for that, but this particular fundraising strategy is one that we don’t want to repeat!

The future will be busy

I’ve been a member of ASABE for 21 years and have known many of the staff and committee members for a long time. However, as only the ninth leader of the Society in its 103 years (and counting) of history, I’m humbled to be in the corner office. My initial goals include fully understanding and representing the Society and its work, raising our profile in the public policy arena, growing the membership, expanding our already excellent level of student involvement, and updating our website so the world can better understand what agricultural and biological engineering is all about.

In addition, I’m still an agricultural engineer, and I’m dedicated to promoting my profession. The future of agricultural and biological engineering will be a busy place!
CNH welcomed as a Title Sponsor for the 2010 AIM

Maria Grazia Barghini, representing CNH, extended gracious hospitality to the ASABE annual international meeting (AIM) attendees at the CNH exhibit, complete with a reception area and several examples of CNH and New Holland equipment.

Ferrari applauds ASABE

ASABE welcomed Diane Ferrari, CNH Senior Director of Production Evaluation, who provided opening remarks at Monday’s general session. Highlighting CNH’s relationship with the Society over the years, Ferrari noted as particularly valuable the company’s enduring support of ASABE standards—which she called “the backbone of CNH designs”—and the International 1/4-Scale Tractor Student Design Competition, from which the company has acquired some of its most talented interns and employees.

POET VP gives keynote

Mark D. Stowers, Senior Vice President of Science and Technology for POET, presented the 2010 Annual International Meeting keynote address, “Ethanol and the Future of Agriculture.” Advances in agricultural and processing techniques as well as improved crop yields are the key factors in the ability of biofuels to reduce reliance on petroleum. Find Stowers’ presentation at www.asabe.org.

Drollinger takes the helm

The ASABE Board of Trustees approved Darrin Drollinger as the new executive director of the Society. In his first opportunity to address ASABE membership, Drollinger expressed eagerness and gratitude to be able to put his education and career to work for ASABE. “I want to work for the best professional society in the world,” he said. “My best hope in securing this reward is to commit my energies, talents, and ideas into making ASABE that society.”

Drollinger will count on the assistance of members in his effort to build a future for the Society that surpasses its considerable accomplishments. The Society’s past, he said, is nothing “compared to what we can do in the future. The members … the volunteers … make ASABE what it is. Together, let’s make it great.”
YPC fun

Trust the Young Professionals Community to inject fun and recreation into AIM. This year’s events hit the high seas. Matt Darr, Jacob Mayer, Tina Schultz, and Ron McAllister begged for their lives in this year’s “All in Good Fun” contest. Schultz was the loser in this event, collecting the least amount of pirate treasure, and she was forced to walk the plank. The YPC’s other recreational endeavors included a leisurely Saturday afternoon river boat excursion aboard the Duchess—or was it the Jolly Roger?—and the annual Fun Run/Walk on a sunny trail that meandered beside the Monongahela River. Andrew Wedel’s young sons warmed up with their dad in the Father’s Day event, in which Wedel took the top honor.

Fellows inducted

The 2010 Class of ASABE Fellows was inducted in a ceremony on June 22. This year, twelve individuals were honored for their outstanding accomplishments. They are:

Robert G. Evans, supervisory agricultural engineer and research leader, USDA-ARS, Northern Plains Agricultural Systems Research Unit, Sidney, Mont., USA.

Richard S. Gates, P.E., professor, Agricultural and Biological Engineering Department, University of Illinois, Urbana, USA.

Larry H. Gay, P.E., tractor historian, author, and retired manager of engineering, John Deere Merchandise Division, Deere & Company, Geneseo, Ill., USA.

Steven J. Hoff, P.E., professor, Agricultural and Biosystems Engineering Department, Iowa State University, Ames, USA.

Fu-Hung Hsieh, P.E., professor and director of graduate studies, Biological Engineering Department, co-leader, Bioprocessing and Biosensing Center, Food for the 21st Century Research Program, University of Missouri, Columbia, USA.

Earle C. Morton, P.E., product safety manager, AGCO Canada Ltd., Oakville, Ontario, Canada.

John A. Replogle, P.E., collaborator, Arid-Land Agricultural Research Center, USDA-ARS, and consultant in Water Resources, Maricopa, Ariz., USA.

Yoav Sarig, P.E., professor emeritus, Agricultural Research Organization, Institute of Agricultural Engineering; chairman, POMEG-TECH, International Projects Consultancy; and consultant, Bet Dagan, Israel. (Not pictured above.)

John K. Schueller, P.E., professor, Mechanical and Aerospace Engineering, and affiliate professor, Agricultural and Biological Engineering Department, University of Florida, Gainesville, USA.

Robert S. Sowell, vice president, Programs and Operations, Council of Graduate Schools, Washington D.C., and dean emeritus, Graduate School, and professor emeritus, Biological and Agricultural Engineering Department, North Carolina State University, Raleigh, USA.

Charles E. Sukup, P.E., president, Sukup Manufacturing Company, Sheffield, Iowa, USA.

Harmon L. Towne, P.E., retired vice president, Engineering and Product Development, Brock Manufacturing, Milford, Ind., USA.
McAllister asks for “just one”

Our Society is only as good as its members, said Ronald McAllister in his inaugural remarks as 2010-2011 ASABE president. “The members create it, and the members can be proud of it.” McAllister encouraged meeting attendees, and all ASABE members, to take the initiative in helping grow the Society. To provide a little inspiration, he and membership director Mark Crossley led the large crowd in a call-and-response chant—“Just one ... more member,”—proving, by McAllister’s tongue-in-cheek assessment, that hanging out with engineers can, indeed, be more exciting than watching paint dry.

Foundation flourishes

The three Foundation events at the 2010 AIM brought in at least $12,000 for the Foundation general fund, and the tally is not yet complete. The Grand View Golf outing was enjoyed by 14 golfers and won by the team of Dan Thomas, Bob Evans, and Ron Elliott. The event was sponsored by Wayne Skaggs, Dan and Mary Withrow, and Janice Janssen. Tuesday evening, “Re-Creation,” a young and vibrant song and dance troupe, entertained 83 guests at the annual Foundation benefit dinner. The evening was a success by all measures but one (see End Note). Sponsors for the dinner were Ron and Sharon McAllister, CNH, Dale and Joyce Zimmerman, Michael Walter, and Sukup Manufacturing Co.

Finally, the 2010 Silent Auction and Raffle was a great success, replete with good-natured bidding battles. Among the highlights were three 2,000-lb skids of potatoes, donated by Walther Farms, which were donated to charity by each of the winning bidders. In addition, a handmade t-shirt quilt, exquisitely crafted by Ellen Nelson, brought in $1400 in a raffle won by Mary Sukup, who generously donated the quilt to ASABE headquarters, where it is now on permanent display.

Robotics and Fountain Wars

Attendees enjoyed observing two on-site student competitions: the Robotics Competition and Fountain Wars. Six teams competed in the Robotics Competition, in which students were challenged to measure twenty trees of varying heights to the nearest centimeter and display the results using wireless communication. Teams earned points for performance, elegance of design, presentation, and a written report. The winner of this year’s Robotics Competition was Kansas State University (for the fourth straight year), with the University of Florida earning runner-up honors.

In the Fountain Wars Competition, teams designed fountains that were then constructed on site. Designs were judged on aesthetics, an oral presentation, construction, and the completion of specified technical tasks. Iowa State took first place and Kansas State took second.

End note

Overall, the 2010 AIM went well—by all but one measure: Some attendees later experienced a gastrointestinal illness. ASABE worked closely with the Allegheny County Health Department in distributing a survey to all annual meeting attendees to discern whether the illness was a result of a food-related source and, if so, which of the annual-meeting venues was implicated. The impressive number of responses—from more than 500 attendees, most of whom were not stricken—facilitated a swift determination that the likely cause was a norovirus, spread by a hotel employee, where the Fellows reception and the Foundation benefit dinner were held. The hotel has expressed deep regret over the outbreak and is taking action to safeguard against similar occurrences. In addition, the hotel is working out compensation details with ASABE, the Foundation, and individuals who incurred expenses as a result of illness.
Process in big-screen plasma TVs can produce ultra-clean fuel

In Brief: The process that lights up big-screen plasma TV displays is getting a new life in producing ultra-clean fuels, according to a report at the 239th National Meeting of the American Chemical Society (ACS). The report described a small, low-tech, inexpensive device called a GlidArc reactor that uses electrically charged clouds of gas called "plasmas" to produce in three steps super-clean fuels from waste materials. One is a diesel fuel that releases 10 times less air pollution than its notoriously sooty and smelly conventional counterpart.

Low-tech and low cost are the guiding principles behind the GlidArc reactors,” said Albin Czernichowski, who presented the report. “Almost all the parts could be bought at your local hardware or home supply store. We use common ‘plumber’ piping and connections, for instance, and ordinary home insulation. Instead of sophisticated ceramics, we use the kind of heat-resistant concrete that might go into a home fireplace. You could build one in a few days for about $10,000.”

Czernichowski noted that the reactors, about the size of a refrigerator, are custom designed to clean the dirty gases produced by low-tech gasification of locally available wastes, biomass, or other resources and produce a clean mix of carbon monoxide and hydrogen gas to synthesize biofuels. Corn farming regions, for instance, could use corn stover as the raw material. In urban areas, waste cooking oil from restaurants could be the raw material. In regions that produce biodiesel fuel, glycerol could be converted into clean fuels. Czernichowski pointed out that production of biofuels results in huge amounts of glycerol byproduct—91 kg (200 lb) for every 907 kg (2,000 lb) of biodiesel. The glycerol is expensive to refine to the high purity needed for commercial use. GlidArc reactors could transform glycerol into a clean synthesis gas (carbon monoxide and hydrogen) for production of fuels, he said.

A professor at the University of Orleans in France, Czernichowski realized in 1986 that a branch of science called non-equilibrium cold plasma could be used to produce new transportation fuels that are less polluting than their conventional counterparts as they lack harmful substances found in traditional transportation fuels.

The technology gets its name from the use of a gliding arc of electricity that produces a plasma inside the reactor. The plasma allows chemical reactions to occur at dramatically reduced temperatures. Gases from heating (pyrolysis or gasification) biomass or glycerol, for instance, become clean and chemically active, and this allows for the transformation of those materials into clean fuels.

“The main advantage of such biobased fuels that the GlidArc technology can create is that they constitute ‘drop-in replacements’ for fossil diesel oil, gasoline, or kerosene, and no modifications are needed in engines, vehicles, and distribution systems,” Czernichowski said. “The biofuels can also be used as additives to various types of engine fuels to improve certain fuel properties. Another important advantage, of course, is their much lower toxicity for people and the environment compared to conventional fuels.

For more information, contact Michael Bernstein, m_bernstein@acs.org; or Michael Woods, m_woods@acs.org.
Nuisance farm odor is focus of Iowa State researcher’s work

In Brief: In the summer months, few people can afford to run their air conditioning 24 hours a day. And even if you could, there are times during the day when you just don’t need it. ASABE member Steven Hoff, an Iowa State University professor of agricultural and biosystems engineering, thinks the same logic should apply to odor mitigation for concentrated animal feeding operations.

Hoff has developed a system for operating odor mitigation systems only when the weather is most likely to cause the odors to become a nuisance to neighbors.

Hoff’s odor mitigation prototype monitors several climate variables and operates only when neighbors may be affected. The system is a miniature weather station that includes locations of neighbors as part of its programming.

“The idea is to keep track of atmospheric stability, which we know affects how far odors will travel, and whether a neighbor may be affected because of the atmospheric conditions—the wind direction, and those types of things,” said Hoff. “But if no one is going to be impacted by the odors emitted from a pig house or a poultry house, then save the farmer some money and don’t mitigate,” he added.

Hoff said the system can be used with any odor-scrubbing system that can be controlled in an on/off mode.

“Whatever the method is, bio-filters, or any other mitigation technique, it will be turned on when the conditions dictate,” he said.

The most important weather aspect of the system is monitoring atmospheric stability. When the atmosphere is unstable, odors will not travel as far and will affect fewer neighbors. When the atmosphere is more stable, odors will travel farther and can be a nuisance to more neighbors, according to Hoff.

“We call it ‘impact-based odor control’ because the idea is to mitigate only when needed,” he said.

Atmospheric conditions that the system monitors most closely are humidity, wind speed, wind direction, temperature, and solar impact. All of these are likely to affect stability. Because two of the important inputs of the system are wind speed and direction, the system can also tell where the odor may be headed.

Hoff and Lun Tong, an adjunct assistant professor in agricultural and biosystems engineering, say that the system can currently can take into account the locations of five different neighbors. Within a year, the system will be able to expand to as many as 20 neighbors that might be affected.

Another benefit of the system is the effect on emissions that have environmental impact. “This is not geared to gas emission reduction; however, one of the side benefits is that we are still mitigating some of the gases that have environmental concern,” said Hoff.

Through two summers of research, Hoff and Tong have developed a system that will provide “significant reduction in operation time while still maximizing the benefit to the neighbor” and also be affordable for the producer, according to Hoff.

Cost of operation is the greatest limiting factor for current odor mitigation systems, Hoff said. This system will allow producers to invest greater amounts in the mitigation system without having to worry as much about operating costs.

For anyone who lives outside the city, as Hoff does, there are tradeoffs. “In my business, everybody has a sensor. And everyone’s sensor is calibrated a little differently. And we all have personal thresholds. My wife’s threshold is lower than mine,” he said. “With this system, we are trying to minimize the odor impact of animal production to become less of a nuisance to neighbors.”

For further information, contact Steven Hoff, hoffer@iastate.edu; or Dan Kuester, kuester@iastate.edu.
Research makes lake and stream conservation more effective

**In Brief:** Michigan State University (MSU) scientists have developed a pioneering, comprehensive approach that makes conserving and managing freshwater lakes, streams, and wetlands more integrated and effective.

"We call our approach landscape limnology," said Patricia Soranno, MSU associate professor of fisheries and wildlife. "It's a new way to study freshwater that considers all freshwaters together—lakes, rivers, and wetlands—as they interact with one another and with natural and human landscapes. Our goal is to improve our broad understanding of the diversity of freshwater resources and to give freshwater managers science-based tools to manage and protect these bodies of water."

Michigan has more than 10,000 freshwater lakes larger than 5 acres, 30,000 miles of streams, and more than 10,000 square miles of wetlands. State agencies, mainly the Department of Natural Resources and Environment, are charged with the enormous task of managing these freshwater resources to make sure all needs are met, including overseeing fish stocking and fishing regulations, monitoring herbicide applications to control aquatic plants, and setting withdrawal regulations and nutrient standards. But with limited budgets, data can be collected on only a small percentage of these aquatic resources.

Landscape limnology uses geographical information systems, or GIS, data from satellites and aerial photos, including information on land use, soils, and geology around the freshwater resources. This information is combined with data collected in the field, such as fish population numbers or nutrient levels in the water, to create models that decision-makers can use to decide on the best management and conservation strategies to meet their goals.

Landscape limnology differs from traditional limnology by looking at freshwater resources as an integrated part of a complex landscape of terrestrial and aquatic elements rather than considering each lake or wetland as a single, isolated entity.

Soranno and MSU co-authors Mary Bremigan and Kendra Spence Cheruvelil, associate and assistant professor of fisheries and wildlife, respectively, said that many current and emerging environmental issues have causes that range in scale from local to global. All three are members of the MSU Landscape Limnology Research Group.

Land-use change, exotic species invasions, and climate change are all complex issues linked in ways that can only be understood by taking an approach that includes all these scales as well as freshwater, terrestrial, and human landscape information.

"A landscape approach that considers what's happening at both the local water-body scale and at the broader regional scale is really the only way to study these types of issues," Cheruvelil said. "If you look at only one ecosystem in isolation, you don't see the whole picture."

"The landscape limnology framework makes it easy to run several complementary models at the same time," added Bremigan. "Right now, the people who manage fish use one model and the people who manage nutrient levels use a completely different model, and they're rarely compatible, so it can be difficult to see how changes in one affect the other. Landscape limnology models make it easier to see the relationships between all the variables."

The MDEQ began using the MSU scientists' landscape limnology approach in 2006 to set and manage nutrient levels in the state's freshwater lakes and streams, and the managers are very pleased with the results.

"The state of Michigan had to present our approach to U.S. Environmental Protection Agency officials, and they gave us a very favorable review," Soranno said. "Now we're starting to work with agencies outside Michigan."

For more information, contact Mark Fellows, University Relations, Mark.Fellows@ur.msu.edu; Jamie DePolo, Michigan Agricultural Experiment Station, depolo@msu.edu; Patricia Soranno, soranno@msu.edu; Mary Bremigan, bremigan@msu.edu; or Kendra Spence Cheruvelil, Fisheries and Wildlife, ksc@msu.edu.
POET plans to cut water use to 2.33 gallons per gallon of ethanol in five years

**In Brief:** Water reduction is the first goal of Ingreenuity, POET’s new initiative to enhance the environmental performance of ethanol.

POET, the largest ethanol producer in the world, plans to decrease water use in the production of ethanol by 22 percent over the next five years as the first goal of its sustainability initiative. If successful, it will cut the company’s water use per gallon of ethanol from an average of 3 gallons to 2.33—an annual water savings of one billion gallons.

POET CEO Jeff Broin said the company is committed to producing ethanol as sustainably as possible and minimizing its impact on natural resources. “Fresh water is a precious natural resource that we do our utmost to conserve. We have seen tremendous efficiency gains in the 22 years I’ve been in this business, but we will continue to do better.”

The reductions will come primarily through installing a proprietary process developed by POET engineers that recycles cooling water rather than discharging it. The Total Water Recovery process has recently been installed in three POET biorefining locations—Bingham Lake, Minn.; Caro, Mich.; and Hudson, S.D. Those facilities now average 2 to 2.5 gallon of water per gallon of ethanol.

Water reduction is the first goal of Ingreenuity, POET’s new initiative to improve the environmental performance of ethanol. The company is developing goals in other areas, including greenhouse gas reductions and the development of bio-based products.

For more information, contact Nathan Schock, 605-965-6428 ext.10428 or (call) 605-759-4809.

Second plant pathway could improve nutrition and biofuel production

**In Brief:** Purdue University scientists have defined a hidden second option that plants have for making an essential amino acid, which could be the first step in boosting plants’ nutritional value and improving biofuel production potential.

The amino acid phenylalanine is required to build proteins and is a precursor for more than 8,000 other compounds essential to plants, including lignin, which allows plants to stand upright but acts as a barrier in the production of cellulosic ethanol.

It had been believed that plants could use two pathways to create phenylalanine. Natalia Dudareva, a Purdue professor of horticulture, and Hiroshi Maeda, a postdoctoral researcher in Dudareva’s laboratory, have confirmed that while plants predominantly use one pathway, they have another at their disposal. The existence of this second pathway might one day allow scientists to increase a plant’s production of this essential amino acid.

“That would allow us to increase the nutritional value of some food,” Maeda said. “But also by increasing these compounds, the plants would be better able to protect themselves from changes in the environment.”

Maeda added that reducing phenylalanine could lead to a reduction of lignin in plants, which would improve digestibility of cellulosic materials for ethanol production.

Phenylalanine is one of the few essential amino acids that humans and animals cannot synthesize, so it must come from plants. It is produced when sugars enter a plant’s shikimate pathway, which creates a link between the processing of sugars and the generation of aromatic compounds. The next steps had not been known until now, and were thought to involve one of two proposed routes—the phenylpyruvate or arogenate pathways.

Dudareva and Maeda found a gene responsible for phenylalanine production, and suppression of the gene expression knocked out 80 percent of the phenylalanine content in petunias. The hypothesis was that the gene suppression would act like a clogged pipe, creating an abundance of compounds that would have later become phenylalanine in a normal plant.

But that’s not what happened.

“These plants knew that the last step of phenylalanine production was down and slowed the first steps,” Dudareva said.
Maeda said the plant created some sort of feedback mechanism that slowed down the entry point of the shikimate pathway.

Dudareva and Maeda wanted to see what would happen if they forced the shikimate pathway to function, so they gave the petunias shikimic acid. The plants were flooded with the upstream compounds as expected, but since they could not use the usual arogenate pathway to convert them to phenylalanine, they used another path that scientists had only theorized existed.

“What this tells us is that this other pathway could be active under certain conditions,” Dudareva said.

Understanding how the pathways work is a first step in finding ways to increase phenylalanine for boosting the nutritional values of foods, or decreasing it, which may help in biofuel production.

Dudareva and Maeda will next try to determine how plants create feedback to the shikimate pathway. Disrupting that feedback could lead to an abundant production of phenylalanine in plants. The National Science Foundation funded the research.

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Biology may not be so complex after all

In Brief: Centuries ago, scientists began reducing the physics of the universe into a few, key laws described by a handful of parameters. Such simple descriptions have remained elusive for complex biological systems—until now.

Emory University biophysicist Ilya Nemenman has identified parameters for several biochemical networks that distill the entire behavior of these systems into simple equivalent dynamics. The discovery may hold the potential to streamline the development of drugs and diagnostic tools by simplifying the research models.

“It appears that the details of the complexity of these biological systems don’t matter, as long as some aggregate property, which we’ve calculated, remains the same,” says Nemenman, associate professor of physics and biology. The simplicity of the discovery makes it “a beautiful result,” Nemenman says. “We hope that this theoretical finding will also have practical applications.”

He cites the air molecules moving about his office: “All of the crazy interactions of these molecules hitting each other can be boiled down to a simple behavior: the ideal gas law. You could take the painstaking route of studying the dynamics of every molecule, or you could simply measure the temperature, volume, and pressure of the air in the room. The second method is clearly easier, and it gives you just as much information.”

Nemenman wanted to find similar parameters for the incredibly complex dynamics of cellular networks, involving hundreds, or even thousands, of variables among different interacting molecules. Among the key questions: What determines which features in these networks are relevant? And if they have simple equivalent dynamics, did nature choose to make them so complex in order to fulfill a specific biological function? Or is the unnecessary complexity a “fossil record” of the evolutionary heritage?

Nemenman and colleagues investigated these questions in the context of a kinetic proofreading (KPR) scheme. KPR is the mechanism a cell uses for optimal quality control as it makes protein. KPR was predicted during the 1970s, and it applies to most cellular assembly processes. It involves hundreds of steps, and each step may have different parameters.

Nemenman wondered if the KPR scheme could be described more simply. “Our calculations confirmed that there is, in fact, a key aggregate rate,” he says. “The whole behavior of the system boils down to just one parameter.”

This means that, instead of painstakingly testing or measuring every rate in the process, researchers can predict the error and completion rate of a system by looking at a single aggregate parameter.

Charted on a graph, the aggregate behavior appears as a straight line amid a tangle of curving ones. “The larger and more complex the system gets, the more the aggregate behavior is visible,” Nemenman says. “The completion time gets simpler and simpler as the system size goes up.”

Just as the discovery of the ideal gas law led to the creation of engines and automobiles, Nemenman believes that such simple biochemical aggregates could drive advancements in health.

For more information, go to http://esciencecommons.blogspot.com/2010/02/biology-may-not-be-so-complex-after-all.html.
Genetically engineered crops need proper management to remain effective

In Brief: Many U.S. farmers who grow genetically engineered (GE) crops are realizing substantial economic and environmental benefits—lower production costs, fewer pest problems, reduced use of pesticides, and better yields—compared with conventional crops, says a new report from the National Research Council (NRC). However, GE crops resistant to the herbicide glyphosate—a main component in Roundup and other commercial weed killers—could develop more weed problems as weeds evolve their own resistance to glyphosate. GE crops could lose their effectiveness unless farmers also use other proven weed and insect management practices.

The NRC report provides the first comprehensive assessment of how GE crops are affecting all U.S. farmers, including those who grow conventional or organic crops. This new report follows several previous NRC reports that examined the potential human health and environmental effects of GE crops.

“Many American farmers are enjoying higher profits due to the widespread use of certain genetically engineered crops and are reducing environmental impacts on and off the farm,” said David Ervin, professor of environmental management and economics at Portland State University, Portland, Ore., and chair of the committee that wrote the report. “However, these benefits are not universal for all farmers. As more GE traits are developed and incorporated into a larger variety of crops, it’s essential that we gain a better understanding of how genetic engineering technology will affect U.S. agriculture and the environment. Gaps in our knowledge are preventing a full assessment of the environmental, economic, and other impacts of GE crops on farm sustainability.”

First introduced in 1996, genetically engineered crops now constitute more than 80 percent of soybeans, corn, and cotton grown in the United States. GE soybeans, corn, and cotton are designed to be resistant to the herbicide glyphosate, which has fewer adverse environmental effects compared with most other herbicides used to control weeds. In addition to glyphosate resistance, GE corn and cotton plants also are designed to produce Bacillus thuringiensis (Bt), a bacterium that is deadly when ingested by susceptible insect pests.

Farmers need to adopt better management practices to ensure that the beneficial environmental effects of GE crops continue. In particular, farmers who grow GE herbicide-resistant crops should not rely exclusively on glyphosate and need to incorporate a range of weed management practices, including other herbicide mixes. To date, at least nine species of weeds in the United States have evolved resistance to glyphosate since GE crops were introduced, largely because of repeated exposure. Federal and state government agencies, technology developers, universities, and other stakeholders should collaborate to document weed resistance problems and develop cost-effective ways to control weeds in current GE crops and in new types of GE herbicide-resistant plants now under development.

Environmental benefits

Improvements in water quality could prove to be the largest single benefit of GE crops, the report says. Insecticide use has declined since GE crops were introduced, and farmers who grow GE crops use fewer insecticides and herbicides that linger in soil and waterways. In addition, farmers who grow herbicide-resistant crops till less often to control weeds and are more likely to practice conservation tillage, which improves soil quality and water filtration and reduces erosion.

However, no infrastructure exists to track and analyze the effects that GE crops may have on water quality. The U.S. Geological Survey, along with other federal and state environmental agencies, should be provided with financial resources to document the effects of GE crops on U.S. watersheds.

The report notes that although two types of insects have developed resistance to Bt, there have been few economic or agronomic consequences from resistance. Practices to prevent insects from developing resistance should continue, such as an EPA-mandated strategy that requires farmers to plant a certain amount of conventional plants alongside Bt plants in “refuge” areas.

Economic and social effects

In many cases, farmers who have adopted the use of GE crops have experienced either lower production costs or higher yields, or sometimes both, due to more cost-effective weed and insect control and fewer losses from insect damage, the report says. Although these farmers have gained economic benefits, more research is needed on the extent to which these advantages will change as pests adapt to GE crops, as other countries adopt genetic engineering technology, and as more GE traits are incorporated into existing and new crops.

The higher costs associated with GE seeds are not always offset financially by lower production costs or higher yields, the report notes. For example, farmers in areas with fewer weed and pest problems may not see as much improvement in terms of reducing crop losses. Even so, studies show that farmers value the greater flexibility in pesticide spraying that GE crops provide and the increased safety for workers from less exposure to harmful pesticides.

The economic effects of GE crops on farmers who grow organic and conventional crops also need further study, the report says. For instance, organic farmers are profiting by...
marketing their crops as free of GE traits, but their crops’ value could be jeopardized if genes from GE crops flow to non-GE varieties through cross-pollination or seed mingling.

Farmers have not been adversely affected by the proprietary terms involved in patent-protected GE seeds, the report says. However, some farmers have expressed concern that consolidation of the U.S. seed market will make it harder to purchase conventional seeds or seeds that have only specific GE traits. With the exception of the issue of seed industry consolidation, the effects of GE crops on other social factors of farming—such as labor dynamics, farm structure, or community viability—have largely been overlooked, the report says. More research is needed on the range of effects that GE crops have on all farmers, including those who don’t grow GE crops and farmers with less access to credit. Studies should also examine impacts on industries that rely on GE products, such as the livestock industry.

For more information, contact Jennifer Walsh, Media Relations Officer; Molly Galvin, Senior Media Relations Officer; or Alison Burnette, Media Relations Assistant, Office of News and Public Information, National Academies News, InternetMailforONPI@nas.edu or news@nas.edu.

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**Work aims to re-engineer algae for biodiesel production**

**In Brief:** A Purdue University researcher will lead a portion of a federally funded effort based at Iowa State University aimed at creating genetically engineered algae for environmentally friendly biodiesel production.

Currently, hydrocarbon fuels such as diesel and gasoline require complex chemical processing to be manufactured and are made primarily from non-renewable fossil fuels, which are being depleted, whereas single-cell algae use photosynthesis and are renewable resources, said John Morgan, an associate professor of chemical engineering at Purdue.

The Purdue portion of the work focuses on creating algae that produce more lipids, the precursor of biofuels. The algae harness solar energy to make lipids from carbon dioxide in the atmosphere.

“Algae now store some of their carbon as lipids, but not enough to be useful in producing biodiesel,” Morgan said. “We need to genetically engineer them to increase the amount of lipids they accumulate.”

The three-year project is funded with a grant of more than $4 million from U.S. Department of Energy and is led by Martin Spalding, a professor in the Department of Genetics, Development, and Cell Biology at Iowa State University. About $1 million of the grant, which is part of the American Recovery and Reinvestment Act, is funding Purdue’s portion of the research, which began earlier this year.

The algae are being grown in a bioreactor in Morgan’s laboratory. Algae carry out photosynthesis using energy from light to convert carbon dioxide into a variety of products, including lipids.

“The carbon dioxide is routed in many directions to produce various products, and we are trying to maximize traffic in the specific pathway that leads to lipid storage,” Morgan said. “We want to maximize the accumulation of lipids, which can then be harvested and turned into biodiesel.”

The Purdue group will create “flux maps” that reveal the speed of reactions along many “metabolic pathways” inside algae, information that should enable researchers to engineer algae to store more lipids.

Other researchers in the project will focus on creating algae that thrive in higher temperatures than natural algae can tolerate. The elevated temperature kills contaminants that hinder algae growth. Another facet of the work will focus on increasing “carbon dioxide assimilation,” the first of many steps leading to lipid storage.

For more information, contact Emil Venere, venere@purdue.edu; or John Morgan, jamorgan@ecn.purdue.edu.
New technique improves efficiency of biofuel production

In Brief: Researchers at North Carolina State University (NCSU) have developed a more efficient technique for producing biofuels from woody plants that significantly reduces the waste that results from conventional biofuel production techniques. The technique is a significant step toward creating a commercially viable new source of biofuels.

This technique makes the process more efficient and less expensive,” says Ratna Sharma-Shivappa, associate professor of biological and agricultural engineering at NCSU and co-author of the research. “The technique could open the door to making lignin-rich plant matter a commercially viable feedstock for biofuels, curtailing biofuel’s reliance on staple food crops. Our eventual goal is to use this technique for any type of feedstock, to produce any biofuel or biochemical that can use these sugars,” says Sharma-Shivappa.

Traditionally, to make ethanol, butanol, or other biofuels, producers have used corn, beets, or other plant matter that is high in starches or simple sugars. However, since those crops are also significant staple foods, biofuels are competing with people for those crops.

Other forms of biomass—such as switchgrass or inedible corn stalks—can also be used to make biofuels. But these other crops pose their own problem: their energy potential is locked away inside the plant’s lignin—the woody, protective material that provides each plant’s structural support. Breaking down that lignin to reach the plant’s component carbohydrates is an essential first step toward making biofuels.

At present, researchers exploring how to create biofuels from this so-called “woody” material treat the plant matter with harsh chemicals that break it down into a carbohydrate-rich substance and a liquid waste stream. These carbohydrates are then exposed to enzymes that turn the carbohydrates into sugars that can be fermented to make ethanol or butanol.

This technique often results in a significant portion of the plant’s carbohydrates being siphoned off with the liquid waste stream. Researchers must either incorporate additional processes to retrieve those carbohydrates, or lose them altogether.

However, researchers from NCSU have developed a new way to free the carbohydrates from the lignin. By exposing the plant matter to gaseous ozone, with very little moisture, they are able to produce a carbohydrate-rich solid with no solid or liquid waste.

“This is more efficient because it degrades the lignin very effectively, and there is little or no loss of the plant’s carbohydrates,” Sharma-Shivappa says. “The solid can then go directly to the enzymes to produce the sugars necessary for biofuel production.” She notes that the process itself is more expensive than using a bath of harsh chemicals to free the carbohydrates, but is ultimately more cost-effective because it makes more efficient use of the plant matter.

The research, “Effect of ozonolysis on bioconversion of miscanthus to bioethanol,” was co-authored by NCSU’s Sharma-Shivappa; doctoral student Anushadevi Panneerselvam; Praveen Kolar, assistant professor of biological and agricultural engineering; Thomas Ranney, professor of horticultural science; and Steve Peretti, associate professor of chemical and biomolecular engineering. The research is partially funded by the Biofuels Center of North Carolina and was presented at the 2010 ASABE Annual International Meeting in Pittsburgh, Penn.

For more information contact, Matt Shipman, matt_shipman@ncsu.edu, or Ratna Sharma-Shivappa, ratna_sharma@ncsu.edu.
USDA to conduct first-ever on-farm energy production survey

In Brief: The USDA has begun conducting the first national on-farm energy production survey. The most recent agriculture census counted more than 20,000 farms and ranches that were producing renewable energy via solar panels, wind turbines, and methane digesters. This survey will further explore how this energy is generated and used.

This survey is a chance for farmers and ranchers to highlight the steps they are taking to produce renewable energy within their operations, which is helping to reduce our dependence on energy from foreign sources,” said USDA Secretary Tom Vilsack. “The survey results will provide agricultural producers, policymakers, and the public with factual data about the economic and environmental implications of on-farm energy production.”

USDA’s National Agricultural Statistics Service (NASS) has mailed the survey forms to farm and ranch operators nationwide who indicated on the 2007 Census of Agriculture that they were generating renewable energy. NASS will publish the survey results in February 2011.

The on-farm energy production survey is the first step in a comprehensive effort by NASS to collect and publish detailed data on the agriculture sector’s production and use of renewable energy.

“This particular survey focuses on the use of wind turbines, solar panels, and anaerobic digesters,” said Hubert Hamer, chair of NASS’s Agricultural Statistics Board. “But we will be expanding our data collection efforts in future years, looking at a full spectrum of issues related to the agriculture sector’s production and use of renewable energy.”

Survey respondents are guaranteed by law (Title 7, U.S. Code) that their individual information will be kept confidential. NASS uses the information only for statistical purposes and publishes data only in tabulated totals.

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Resource file photos for Visual Challenge on opposite page, counterclockwise from top right:


“Noxious smoke.” Photo by ASABE member Paul Caliari (who operated the Alco RS-3 #109) accompanying his Letter to the Editor, August 2006.

“Grieco’s flame.” (Hot water boiler at Penn State’s Research Farm with burner pulled out for demo purposes to show flame while burning plastic fuel. Photo by James Garthe for his feature, “Heating with Plastics,” April 2005.

“Valuable trace fractions.” Illustration by Mike Perkins, James Franz, and Erich Vorpagel for “Good to the Last Drop” by Rick Orth, Charles Abbas, and Rene Shunk, March 2003.

AE50 2010 award winner, Austoft 8000 Series Sugar Cane Harvester, Case IH, as shown in March/April 2010.
LAST CALL!
AGRICULTURAL AND BIOLOGICAL ENGINEERING
Visual Challenge!
ENTRY DEADLINE: SEPTEMBER 30, 2010

As an engineer, you are proficient in science and technology, and you have to be a good communicator as well. In fact, engineers have a unique responsibility to communicate technical concepts to a larger audience. Traditionally, we have done that with words and numbers. Increasingly, we communicate in images.

Visual imagination combined with technical skill can produce astonishing—and deeply informative—images. To call attention to and celebrate the visual aspects of agricultural and biological engineering, Resource is announcing the first-ever Agricultural and Biological Engineering Visual Challenge.

The theme is visual communication of agricultural and biological engineering, and the Challenge is open to all—members, non-members, engineers, and non-engineers. To participate, submit one or more entries in any/all of three categories: photographs/captured images, illustrations/drawings, and informational/explanatory graphics.

Entries will be judged on their visual appeal, clarity, or explanatory power (according to the entry category) as well as their relevance to the Challenge theme. Use your entry to convey the beauty and meaning of your work, your research developments, and your Society division. All entries should be original work. The Challenge is an opportunity to be creative and to show those outside the ABE field: "This is what we do."

Submit your entry as an e-mail attachment in jpg format (300 dpi or higher) to Glenn Loing (laing@asabe.org). Enter "Visual Challenge" in the subject line, and include your full name, professional affiliation, contact information, and a title with brief description of your entry in your message. If necessary, include a source credit and an assurance that permission has been granted to submit, and possibly reprint, the entry. Multiple entries are welcome.

The winning entries will be selected by Resource staff and published in the November/December 2010 issue of Resource.
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