FOOD SAFETY BALANCING ACT
Risk-Based Process Development
Who and what we are today is the product of our predecessors and our own experiences. The rich and sometimes turbulent 100-year history of our association has shaped the look, feel, and culture of ASABE today. How we adapt to the future is largely in our own hands. This issue of Resource includes a number of examples of how our members are working toward a better future for our organization, our professions, and the constituencies around the globe we serve.

The design of agricultural and biological technical works can easily be traced back to the irrigation systems, food storage, fermentation facilities, and other works in Mesopotamia and elsewhere in the Middle East at least four thousand years ago. From the earliest signs of social order, the role of engineer has persisted. In all cultures some folks are recognized and rewarded for having the gift of invention, design, and problem solving. Some are even anointed with the title of engineer.

The identified role of an engineer is a social construct. Through time and situation, the status of engineers rises and falls like the tide — not as regular but just as certain. Engineers in general, and engineers of our ilk in particular, made it possible to irrigate vast areas of arid land, produce high quality food for burgeoning populations, and free millions from the drudgery and risks associated with farming to pursue other careers in urban centers. We have also spent our fair share of time in the dunce’s seat for the real and perceived injustices and unintended consequences of our actions.

Today, we are again in the middle of dramatic social change, and our members are important contributors to the technological and social debates. Renewable energy, food quantity and quality, sustainable ecosystems, and quality of life are all within the purview of ASABE and our members. One indicator of the intense effort is that more than one thousand presentations have been proposed for our 2009 Annual International Meeting in Reno, Nevada, USA, June 21-24. Please join me and other members as we learn about the latest technological advancements, participate in lively discussions, and debate as to how we make the world a better place for all.

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Editor,
The central message given by Mark Riley in the October issue of Resource, that a systems approach is necessary in order to appreciate fully the outcomes of engineering applied to biology, is one that I agree with very much. As Mark has noted, the genome isn’t the only determination of biological outcomes; each biological unit is a product of the interactions it has with its physical, chemical, and biological environments, something that has been taught in agricultural engineering since before I went to school. The problems are several:

1. Environmental conditions are chaotic in the mathematical sense of the word.
2. Individual genes in the genome may or may not be activated.
3. Cultural practices passed from older to younger generations are a parallel legacy of information and behavioral outcomes.
4. Biological units are adaptable and changeable.

That is why engineers need to learn about biology differently from the way biologists learn. Engineers need principles and basic concepts related to utilization, and they need the ability to avoid unintended consequences that are likely when dealing with living things.

As to the difference between civil engineering designs and biological engineering designs, one major difference is the time that civil engineers have had to develop empirical knowledge to help avoid disasters. Biological engineers have been in business a much shorter span of time, and the range of applications is so much greater than it is for civil engineering, that it will take a long time to catch up.

Lastly, I think the real biological revolution is exhausted. By that I mean that most, if not all, of the basics are now known. What is left is to fill in the details, and there are certainly many to fill in. There are application opportunities galore, and these will continue to expand as long as anyone can imagine. Products and processes hardly considered possible until recently will become reality within the foreseeable future. Distinctions between the physical world and the biological world will blur, and we will have empirical models assisting in the designs of nearly all aspects of life. It’s almost scary.

Sincerely,

Arthur T. Johnson, University of Maryland Department of Bioengineering, artjohns@umd.edu
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ON THE COVER
Food safety issues are a little like high-wire walking. Applying a risk-based approach to process design for the sake of global food safety and improved trade is a balancing act. Illustration credit: dreamstime.com and Scott Bauer at USDA-ARS.
Natural-air grain drying offers an unusual opportunity for shelled corn, soybean, and specialty crop producers to participate in the green revolution by reducing their consumption of fossil fuels. It is a low-energy drying system that typically cuts energy costs by as much as two-thirds (based on autumn 2008 energy prices) compared to more commonly used high-temperature drying systems. The low-energy drying system resulted from research work done primarily by agricultural engineers in Minnesota and Indiana decades ago. The principles haven’t changed, but the energy costs have!

What is natural-air grain drying?
Natural-air grain drying is an in-bin drying system traditionally composed of the following characteristics:

• The drying process is slow, generally requiring three to four weeks.
• Initial moisture content is normally limited to 22 to 24 percent.
• Drying results from forcing unheated air through grain at airflow rates of 1 to 2 cfm/bu.
• Drying and storage occur in the same bin, minimizing grain handling.
• The bin is equipped with a full perforated floor, one or more high-capacity fans, a grain distributor, and stairs.
• Cleaning equipment is used to remove broken kernels and fines.

Modern natural-air grain drying can include additional up-to-date technology:

• Sensors that measure air temperature and humidity outside and stored grain temperatures inside the drying bin.
• Small heaters that lower the relative humidity of air as it enters the fan during nasty weather and night-time conditions that otherwise would not allow grain to dry.
• Electronic controllers that monitor air quality measurements and “decide” when fans and heaters should be on or off.
• Gravity spreaders that level grain and distribute fine particles, providing a uniform drying front across the bin.

For removal of only 10 points of moisture, energy required and associated costs for natural-air drying are approximately one-third of that required for high-temperature drying, whether or not in-dryer cooling or in-storage cooling is done. The process minimizes or avoids the use of propane (which has tripled in price from U.S. $0.75 to $2.25/gal in two years) while depending on the free energy that is available from natural air. While the quantity of electrical energy used for natural-air drying is much higher, the overall energy consumption is significantly lower.

How do new technologies lead to success?
A major challenge for successful grain storage and handling is the measurement and monitoring of the moisture content of the crop from harvest until it is marketed. Grain that is too wet too long will spoil and rot; grain that is over-dried...
implies that energy was applied unnecessarily and wasted. There is typically no marketing premium for over-dried grain. Instead, the reduction in product weight leads to lost revenue for the farmer.

A key to on-target drying is measurement of the temperature of the air after it has entered the bin and before it moves upward through the grain. This measurement accounts for the heat energy increase and associated temperature rise in air caused by the action of fan blades plus heat energy added as the air passes over the fan motor in the case of axial fans. A valuable option is to have the controller programmed to use a small grain bin heater. During cool fall weather, the heater can be used to increase the temperature of the drying air a small amount (17° to 16°C or 1° to 4°F) while correspondingly lowering the relative humidity. This adds flexibility to the process by allowing drying to continue in less desirable, low-temperature/high-humidity harvest-time weather, particularly after sundown.

Can other crops be dried with natural-air systems?
Soybeans are an alternative crop for Corn Belt growers. Bins that are equipped for natural-air drying with electronic controllers are ideal companions for efficient soybean harvesting. At the 18 percent moisture level, there is less combine header loss due to shattering. Avoiding the loss of even one bushel of soybeans per acre would pay for the cost of drying. Harvesting can begin earlier in the morning and continue late into the evening. Perhaps even more advantages accrue because harvesting can continue without costly delays at a time of the year when every hour is critical. The controller can also be set to avoid drying when the relative humidity is below 40 percent, thus avoiding seed coat cracking and splits. These quality characteristics are critical when beans are being stored for seed production.

A specialty crop known as low linolenic soybeans enables food processors to significantly reduce the trans fats in processed soybean oil. Approximately 10,117 ha

<table>
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<th>Drying System</th>
<th>Fuel Energy</th>
<th>Electrical Energy</th>
<th>Totals[c]</th>
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<td>Propane (gal)</td>
<td>Cost[c] ($)</td>
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<td>Dryeration</td>
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<td>140</td>
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</tbody>
</table>

[a] These estimates are only intended to help compare grain drying alternatives. Energy use and prices vary widely from one system and/or area to another.
[b] Total energy in units of 1000 Btu.
[c] Energy costs were assumed to be $1.50/gal for propane; $0.10/kwh for electricity.
[d] Costs may be 30 percent less where power companies offer discounted pricing for grain drying when electricity is the sole source of energy.
(250,000 acres) were planted in Ohio in 2007, with expectations for over 20,2343 ha (500,000 acres) in 2008. Farmers were getting a $0.60 U.S. premium for low linolenic soybeans in 2007, but the contracts require that the beans be stored on the farm and kept in good condition. This premium alone pays to equip a storage bin for natural-air drying in less than two years, including a controller and a gravity spreader. Other food-grade crops that have been dried and stored successfully with natural-air drying technology include popcorn, food-grade white corn, food-grade yellow corn, high amylase corn, canola, and rice.

Pioneer Hi Bred International, Inc., marketing personnel are now promoting seed corn for crops that are expected to provide above-average ethanol yield potential. They are designated as high total fermentable (HTF) hybrids. These ethanol corn hybrids deliver higher levels of fermentable starch, resulting in higher ethanol output. Currently, more than 180 Pioneer HTF ethanol hybrids are available across a wide range of maturities. Their fact sheet states that cooler drying temperatures are required when drying this type of corn. Excess temperatures can lower ethanol yields. High-technology electronic controllers can contribute to meeting quality standards expected by ethanol producers. Ethanol plants typically store no more than 15 to 30 days of their production capacity. This implies that on-farm storage is critical. Ethanol plants will be expecting the same quality of corn in August that they expect at harvest time.

Can feed corn be air-dried over the winter?

Significant savings in drying costs can be realized when corn is harvested and stored over winter for animal feed. Corn that is harvested at 17 to 18 percent moisture content (MC) anytime after November 1 can be stored without drying until April 1. Corn at these moisture levels is often preferred by growers, who observe that the feed is more palatable for their livestock. Storage bins that are equipped with fans and electronic controllers for natural-air drying can be used to aerate and maintain the quality of 18 percent MC corn throughout winter months. Any 18 percent MC corn that remains after April 1 can then be dried if needed.

Who uses natural-air drying systems?

Ron Neill lives north of Bellevue, Ohio, where his farm is located approximately 24 km (15 miles) south of Lake Erie. He farms close to 1,214 ha (3,000 acres), and typically half of his land is planted to corn each year. Neill has been using natural air to dry his shelled corn since the early 1970s. He does this with a series of 30-ft diameter (D) × 9-ring bins. He installed a Bullseye Moisture Controller on one of his bins two years ago. Neill stated that the controller paid for itself in one drying season. As a result, he installed three more controllers on two bins he had built previously and a third one on a newly constructed bin in 2007.
A supporting testimonial for natural-air drying systems comes from Keith Edwards, Ron Neill’s neighbor less than 3 km (2 miles) to the north. Edwards grows over 1,619 ha (4,000 acres) of crops, with corn production coming from approximately 809 ha (2,000 acres). He is equipped to harvest up to 3,000 bushels of corn per hour. All of the corn that is dried on his farm is dried with natural air. There are no propane tanks to be seen on his farmstead. Edwards has expanded his bin capacity as his farm has grown. He started drying with natural air over 30 years ago. He currently has five 36-ft D × 9-ring bins plus a 60-ft D × 9-ring bin. All six bins are equipped for natural-air drying. These bins provide drying and storage for over 165,000 bushels of shelled corn.

Edwards does not use electronic controllers. He is afraid they would lead to complacency, i.e., he wouldn’t be inclined to crawl up into his bins to check the progress of the drying as frequently as he should. Edwards also talked about the high test weight, high quality corn he achieves with his natural-air drying systems. He has a regular customer in eastern Ohio who pays a premium of $0.25/bu plus costs of trucking for the high test-weight corn. A rule of thumb for natural-air corn drying is that the cost per bushel for drying is about equal to the cost of electrical energy per kilowatt-hour. Edwards said he was paying only $0.07/kwh during the 2006 harvest season. This suggests that the premium he was paid for high-quality corn covered the costs of energy for natural-air drying more than three times over.

Natural-air drying is a good option for farmers looking to store corn on their farm long-term either for livestock feed or to compete in the marketplace as a shelled corn supplier to an ethanol plant. Farmers tend to shy away from the system because there are restrictions on the magnitude of incoming moisture content and management requirements are high, but in the long run, it is well worth it.

The mention of trade names of companies in this feature is for information only and does not imply endorsement by the Ohio Agricultural Research and Development Center/The Ohio State University or ASABE.

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Complex algorithmic data processing and networking schemes gathered in the digital realm of integrated circuitry often dominate the world of wireless sensors. However, no wireless device is useful unless it can establish a radio link in the challenging environments found in agriculture. The interface of radio waves, antennas, and carrier frequencies is often overlooked. Appropriate application relies on understanding the operational limitations and needs relative to this interface, and not necessarily the complex technical features (i.e., network protocols, modulation schemes) of such systems. Researchers, engineers, students, and producers not familiar with fundamental radio operations can better apply wireless sensors by understanding the following key areas.

Waves vs. wires

Wireless communications are facilitated with electromagnetic (EM) waves known as radio frequency (RF) waves. RF waves have virtually replaced wires as an electronic transport medium. RF waves cannot be seen, unlike wires, yet they still provide a connection between electronic devices. Like wires that can be damaged or cut, EM media can also be disrupted, thus compromising wireless communication links.

RF waves can bend around obstacles, go through objects, reflect off structures, and exist as a pre-installed component. However, these advantages are accompanied with a new set of impediments. Not all objects can be fully penetrat ed by RF waves, resulting in attenuated signals or propagation losses. Waves bending around and reflecting off structures are not necessarily supportive traits, as they can cause signal cancellations, although some objects may reflect waves to shadowed receivers, thereby providing an enhancement. It is worth taking time to become aware of the structures within and nearby communication paths, and how these structures potentially alter radio performance.

RF waves cannot pass through conductive materials, known as shields (i.e., metal buildings), and they are weakened by energy absorbing/dissipating materials (i.e., water, vegetation, animal flesh) because of molecular relaxation and resonance. Permittivity and conductivity describe the physical characteristic of materials encountered by RF waves.

Materials will either conduct electric current, depleting energy from the wave, or permit the wave to pass.

In agricultural environments, and all scenarios, clear air is the best medium for RF waves. Line-of-sight is used to describe open-air situations where the receiver and transmitter communicate by a straight path, with unobstructed RF signals. For example, two devices located on opposite sides of a herd of cattle, a wide strip of trees, or a metal barn will experience signal attenuation (fig. 1). Such situations are remedied by repositioning devices so they are closer together or have a clearer line of sight.

Earth and ground

Earth ground can cause significant attenuation by acting as a dielectric material. It is not likely that short-range wireless devices will need to transmit through a mountain, but it may be desirable to transmit from a buried soil sensor. Antennas located near ground will experience signal attenuation for two main reasons: induced current in the antenna from nearby reflections and signal interference from reflected waves. When a near-ground antenna transmits a wave, the wave may be reflected back to the antenna, inducing a significant current in the antenna. This will cause a change in the antenna’s radiation because the induced current will either increase or decrease the transmitted power, along with potential alterations of the antenna system’s electrical characteristics (i.e., detuning). Signal interference can also be caused by ground-reflected waves in the antenna’s far field region. At shallow reflection angles, waves change phase and polarization. Shallow angle waves can partially cancel stronger non-corrupted waves. Wave cancellation is minimized by creating greater reflection angles via high antenna positioning.

Novice users may make the mistake of positioning wireless...
devices near ground because that’s easier than installing the device on a vertical structure. Minimum aboveground positioning can be determined by the operating wavelength. For example, a 900 MHz device has a wavelength of about 0.33 m (1.08 ft). A workable height would be greater than at least one wavelength of the operating frequency, and better performance would occur at multiple-wavelength heights.

**Frequency and power**

Two important constituents of RF waves are carrier frequency and transmission power, and they are strongly related to the physical aspects of wireless sensor applications. Carrier frequency is the center of a particular RF bandwidth. For instance, a 915 MHz carrier frequency with a 10 MHz bandwidth encompasses bands from 910 to 920 MHz. Bandwidth affects to data rate and the number of modules manageable on a wireless network. Bandwidth is also an antenna characteristic determined by size and shape.

Transmission power is applied to a device’s antenna in order to generate EM energy in the form of RF waves. For a given transmitter power, a low-frequency signal is able to travel farther than a high-frequency signal (fig. 2). Wavelength and objects in the propagation path partially dictate performance. Waves are more apt to bend around objects not larger than one wavelength. For example, a 2.4 GHz signal has a wavelength of 12.5 cm (4.9 in.) and will have difficulty bending around larger obstacles like tree trunks. Higher frequencies can accommodate higher data rates, thus using less power per unit of data. High-frequency devices need more power to transmit the same distance as devices using lower frequencies, a design trade-off.

Low frequencies typically need a larger antenna. Since size and concealment are often important for wireless sensors, antenna shape may play a significant part in frequency selection. When selecting a wireless system, it is imperative that the trade-offs related to power usage, carrier frequency, data throughput, and size are understood.

**Antennas variations**

Many antenna designs have been integrated as copper traces on circuit boards or as board-level surface-mounted components not visible to normal users (fig. 3). More conventional antenna shapes include small stubs, wire-like protrusions, or patches (fig. 4). Antennas have directional radiating features, and their performance varies relative to orientation and distance.

An antenna’s primary purpose is transmission and reception. Antennas convert energy from a transmitter into radiated electromagnetic energy, and they convert electromagnetic energy from an RF wave into voltage and current that are fed to a receiver. Transmitting antennas must radiate so that the receiving antenna can accept the signal. Likewise, a receiving antenna requires positioning so that it can interface correctly with a signal.

RF signals lose energy with distance (fig. 2). Enough power must be directed to the area where a receiver is located. Antennas can direct transmitted power, so radio signals depend on antenna orientation and direction.

Other than orientation, antenna size and design must also be considered. If the antenna was designed for a high-frequency signal, then it would have difficulty receiving low frequencies. All of this means that antennas and signals must be used within prescribed parameters.

**Transmitting and receiving**

Receiving and transmitting devices do not necessarily need identical antennas. Different styles of antennas can send and receive signals to each other, usually with decreased performance. However, it is best to have similar types of antennas on all devices (possibly excluding stationary base stations) with similar orientation and radiation patterns. For example, a wireless sensor module with a 1/4-wavelength whip antenna is usually positioned with its antenna vertical. Whip antennas are designed to radiate a signal in an omnidirectional pattern. However, “omnidirectional” refers to a 360° pattern in the horizontal plane parallel to the surface of the Earth (fig. 5). A vertical whip antenna radiates very little in the upward or downward paths, known as null directions. A receiving whip antenna would therefore need to be vertically aligned, and at a similar height. Figure 6 illustrates the best whip antenna positioning between a transmitting device, located at the center of its toroid radiation

![Figure 2. Degradation as result of transmission distance for 300 MHz to 2.4 GHz frequencies.](image)

![Figure 3. Board-level integrated antennas. Chip (left) and copper trace (right).](image)
pattern, and a receiving device located in the rightward direction. A line can be drawn perpendicular to these antennas, indicating that the receiver is well located in the horizontal plane of the transmitter’s radiation pattern. Two non-receptive devices are also shown in figure 6. One is directly above the transmitter in a null region, and the other is rotated 90° to the transmitter while still in the plane of the radiation pattern.

The idea is to know where and how wireless devices can be located for any given application environment. Micro-sized GPS devices are a good example of orientation dependency. Handheld and vehicular GPS devices commonly use “patch” antennas made of two square copper patches separated by a ceramic plate (fig. 4). The antenna’s design has a wide upward directivity when horizontally aligned. This style of antenna is meant to lie horizontal with the receiving patch facing up, so that satellites can be viewed. Signals from satellites located on the horizon are hard to receive, but satellites transmitting signals at shallow angles above the horizon (i.e., 30°) can usually be received.

When GPS patch antennas are vertically aligned, the number of viewable satellites is reduced to less than half those located in the upward hemisphere, making an accurate positioning unlikely. Agricultural research applications, such as tracking cattle, have obvious concerns with GPS orientation due to animal mobility and body positioning. GPS devices should be fixed to the animal so that the antenna orientation is within an acceptable view of satellites for time durations defined by the application requirements. This may also affect power consumption, because some GPS device configurations use more power when usable satellite reception is infrequent. Scenarios involving metallic trailers, forest canopies, and canyons must also be considered. Newer micro-GPS antenna designs have recently been introduced that are more tolerant of orientation issues.

**Polarization and propagation**

Propagation is the direction and path that a radio wave travels, and polarization describes the electric field vector along the propagation path. Linear, circular, or elliptical are the standard terms used to describe polarization. Linear is when the electric field is aligned in a single plane, whereas circular and elliptical refer to a spiraling field vector.

Antenna-signal polarized matching is affected by antenna orientation, design, and media-induced wave alterations. Antennas are designed to have a particular polarization. Like threads on a nut and bolt, antennas and RF waves must match to work together. If a bolt has right-hand threads, then a nut with left-hand threads cannot be fastened to it. Wireless communications are similar in that an antenna with right-hand circular or elliptical polarization would have difficulty receiving a reverse-polarized signal. Furthermore, a linear-vertical polarized RF wave would have difficulty being received by a linear-horizontal antenna.

Optimized antenna orientation promotes the best wireless communication performance. But when physical position alterations are made, a change in performance is not always noticeable, unless the user is equipped with sophisticated RF instrumentation. The user may not be aware of marginal performance until more strenuous dynamic events occur, such as increased data requirements or foliage growth in the propagation path.

Figures 5 and 6 illustrate an omnidirectional pattern for a typical monopole antenna. The radiated doughnut-like pattern also has a significantly noticeable beam width. Beam width is defined as the angle where at least half the maximum gain (3 dB) remains in the radiated field. Antennas at various locations within the beam width can communicate at considerable distances. Still, the strongest communication is achieved when antennas and waves have matching polarization, are aimed in a clear path direction, and are at similar heights.

Reflected waves and waves passing through dielectric media can experience polarization and phase alterations. For example, linear-polarized antenna radiates a linear-polarized wave that is reflected off nearby structures or passes through various media, such as loose brush or trees. The linear signal is time varied and rotates in an unpredictable manner along the propagation path, thus becoming re-polarized and phase shifted. In this case, a circular-polarized or multipath antenna would be more likely to receive the signal compared to a matching linear-polarized antenna. This approach increases

**Figure 4. Common antenna designs. Monopole whip (left), patch (upper right), and helical stub (lower right).**

**Figure 5. Radiation pattern of monopole antenna on wireless sensor device. Three-dimensional model (upper left), 2-D slice of 3-D model (lower left), horizontal plane (upper right), and vertical plane (lower right).**
the possibility of capturing portions of the electric field vector. Even though antenna mismatch may help prevent communication failure, it is also known to reduce transmission distance.

**Direction, distance, and dB**

An isotropic antenna is an ideal theoretical antenna that performs equally well in all directions when transmitting and when receiving. Isotropic antennas provide a basis for describing how well an antenna can perform. The performance measure for wireless communications is always relative. A benchmark is selected, and everything else is compared to it, usually in the form of a logarithmic ratio. Decibel (dB) is the unit used for this relative measure. However, dB alone does not provide meaningful information unless it is clear what base is used. Wireless sensors are commonly rated using dBi and dBm. The unit dBi indicates decibels with an isotropic radiator as the base comparison, and dBm indicates a base of 1 mW fed into 50 ohm impedance (common for wireless sensors). Decibel is a tricky unit to understand because it has multiple parts to consider. Simply reading 5 dB from a specification sheet does not have significance without some understanding of the measurement reference and how the value is intended to be applied.

**Directivity, efficiency, and gain**

Directivity, efficiency, and gain all must be considered to comprehend decibel transmission and reception. Directivity is how well an antenna radiates in a particular direction as compared to an isotropic antenna. If a test antenna’s planar radiation pattern exhibits greater than 0 dBi for 180° in the forward direction and less than 0 dBi for 180° in the rearward direction, then the test antenna can transmit farther than an isotropic antenna in the forward direction and less in the rearward direction. Directivity essentially describes the antenna’s effectiveness when aimed. High directivity indicates longer transmission distances, and low directivity represents shorter transmission distances. When comparing the directivity of an isotropic antenna to a real antenna, remember that they are transmitting the same amount of total power. The real antenna simply redistributes the power differently. This redistribution is where antennas attain their directivity.

Antenna efficiency is the power input of the antenna relative to the power that is actually transmitted. The product of directivity and efficiency yields antenna gain. It is common to expect gain and directivity to be practically the same, as well-designed antennas are near 100 percent efficient. Directivity and gain are normally provided in the form of 2-D charts, which show dBi measurements for a full 360°. Horizontal and vertical plane charts are often provided as substitutes for full 3-D transmission patterns. Some refer to horizontal and vertical plane charts as E-plane and H-plane, respective of the electric and magnetic components of the electromagnetic field. Figure 5 shows 2-D and 3-D charts.

Directivity-gain charts are used to match application needs. There is a trade-off with antenna gain and directivity. When an application needs long distance, it will need an antenna with high gain (distance can also be achieved with higher transmitter power or lower carrier frequency). But if the application also needs multiple directions, then an antenna with a lower maximum gain and multidirectional radiation pattern is needed. High-gain antennas and multidirectional radiation patterns do not come in the same package. The user must choose which kind of antenna system best supports the application. For long-range multidirectional applications, a networked system of intermediate-range devices may be more appropriate, a value well recognized within wireless sensor networks.

Power measurements, such as sensitivity, are usually indicated by dBm values. Sensitivity is the minimal amount of power needed by the receiver to process a signal. Bit error rate concerns demodulation failure and is typically integrated with sensitivity rating. For example, a GPS device specified at -140 dBm sensitivity is better than one with -120 dBm, because -140 dBm indicates better ability to receive weaker signals. Alternatively, if transmission powers were being compared, then a higher dBm value is more desirable, as it indicates a stronger transmission signal. Sensitivity and transmission dBm values are exactly opposite in the interpretation of their performance values.

The specified transmission ranges on data sheets are likely based on a clear line-of-sight situation, with a sufficient height above ground, in the maximum gain direction, and at maximum transmission power. In other words, distance specifications should be assumed as the best case scenario unless stated otherwise. Be conservative when evaluating specified transmission distance. Expectations of achieving data sheet values are usually not met. Using either 1/2 to 3/4 of the specified transmission distance will help prevent data loss and frustration.

This discussion was intended to help those who use wireless devices but who don’t have a strong background in the area. Hopefully, this information will assist in supporting better wireless sensor use and reach more applications.

**The author would also like to thank John Solie, Oklahoma State University Biosystems Engineering Department, for advisement and revision assistance.**

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As more consumers demand nutritious, fresh-like, prepared ready-to-eat, and heat-and-eat foods in convenient packaging, scientists and engineers have fueled a surge in the development of new processing technologies aimed at delivering numerous high-quality shelf-stable and extended shelf-life (ESL) foods. As existing technologies are refined and novel microbial inactivation technologies are developed to meet consumer demands, there is a growing need for a metric that can be used to judge equivalent levels of hazard-control stringency in order to ensure food safety.

Increased concern over microbiological food safety in terms of public health and international food trade has led to a shift in how microbial risks are assessed and controlled. Widely varying, and often vague, national and international food regulations lead to inconsistencies in processing treatments that impart barriers to trade. As a direct result of the conflict between national food legislation and the general requirements of world food markets, the Codex Alimentarius Commission implemented principles for the establishment of microbiological criteria for foods in international trade (CAC/GL 63-2007) that are addressed in the joint Food and Agriculture/World Health Organization food standards program. Since then, governments around the world have begun adopting a risk-based approach to food safety management.

Historically, the major advances in consumer protection have resulted from the development and implementation of hazard analysis and critical control point- (HACCP) based targeted control measures at one or more steps along the food chain. However, current regulations governing food safety do not target a process endpoint. For example, the FDA Juice HACCP regulation (21 CFR 120) stipulates a 5-log pathogen reduction, and FDA low-acid canned foods regulations (21 CFR 113) require “commercial sterility.” A number of new food safety management metrics have been established in the Codex Alimentarium, one of which is the Food Safety Objective (FSO). The FSO is an output-oriented metric that designates the maximum level of a hazard (e.g., the microorganism or toxin) tolerated in a food at the end of the food supply chain, at the moment of consumption.

FSOs are used to derive performance criteria at control measures upstream in the food supply chain to achieve a target endpoint level. Control measures are the actions or activities used to prevent, eliminate, or reduce a food safety hazard to an appropriate level of protection (ALOP). When establishing performance criteria, consideration must be given to three general categories for control: controlling initial levels ($H_0$), reducing levels ($\sum R$), and preventing an increase in levels ($\sum I$). The outcomes of control measures...
can be applied to evaluate the efficacy of a process by establishing a performance objective. When applying the FSO approach, a performance objective would preferably be less than, but at least equal to, the FSO, which can be expressed by the following equation:

\[ H_0 \cdot \Sigma R + \Sigma I \leq \text{FSO} \]

where \( H_0 \), \( \Sigma R \), \( \Sigma I \), and FSO are expressed in \( \log_{10} \) units. Variability exists at all levels of control; therefore, \( H_0 \), \( \Sigma R \), and \( \Sigma I \) should be derived mathematically in quantitative terms, with a mean and standard deviation being preferred. They should be described, when possible, with an appropriate distribution, such as normal, log normal, or binomial. Factors known and unknown can heavily influence estimates. For this reason, it may be desirable to consider a worst-case scenario for estimates.

**Deterministic example**

If an incoming bioburden of 10 cfu unit\(^{-1}\) is assumed to be worst case for a refrigerated ESL food, then the performance criterion can be established for the reduction necessary to achieve a target FSO of \(-5 \log_{10} \) cfu unit\(^{-1}\) (1 cell per 100,000 units):

\[ H_0 \cdot \Sigma R + \Sigma I \leq \text{FSO} \]

\[ 1 - \Sigma R + 0 \leq -5 \]

\[ \Sigma R \leq 6 \]

However, if the initial bioburden could be controlled to a lower level, for instance, 1 cfu unit\(^{-1}\), then the performance criteria could be met with a milder treatment (\( \Sigma R \leq 5 \)).

Although simple deterministic models like this are useful for illustrating concepts, for the greatest value in decision-making and the setting of performance criteria, stochastic models are needed to capture variability. Monte Carlo simulations are often used to predict outcomes of stochastic risk-based models.

**Setting the FSO**

When employing a novel process, such as high pressure, or a chemical sterilant such as peroxyacetic acid, it is important to select the appropriate target microorganism. For instance, *Clostridium botulinum* spores may be more resistant to high-pressure processing than traditional surrogates used for thermal process validation; however, *Clostridium botulinum* spores appear much less resistant to peroxyacetic acid than *Bacillus cereus*. A proper risk-assessment is necessary to provide the scientific advice needed to select appropriate control measures to be implemented that will achieve the desired level of consumer protection against the microbial hazard(s) in the food. Given the hazard-food combination, an expert panel may be necessary to develop recommendations on the appropriate FSO based on severity, risk, and likelihood of occurrence.

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**In search of the silver bullet**

Since there is no silver bullet technology, particularly for minimally processed foods, in recent years particular attention has been placed on the “hurdle” approach to food safety, that is, combining multiple interventions to reduce pathogens in foods. The application of the FSO approach may allow for flexibility in product formulation and in choosing the processing technologies that achieve the same target endpoint; however, from a public health perspective, one must understand the impact that various control measure combinations have on the safety of the food being produced. When a hurdle approach is employed, the effectiveness of any single control measure is often dependent upon the complex interactions between several control factors, such as pH, water activity, or antimicrobial agents. Often, only a small change in the level of one factor may lead to a microbiologically unsafe food if not appropriately compensated by another control factor.

**Benefits of the FSO approach**

The FSO approach moves away from prescriptive control measures to risk-based process development that may allow flexibility in how a targeted outcome is achieved. Benefits of risk-based process development using the FSO approach are as follows.

For government, this approach offers an internationally accepted, science-based approach for assessing public health risk. This approach can be used to assess whether foods imported from other countries have been produced in a manner that provides an equivalent level of protection to that required for domestically produced foods. This risk management approach may also be used to assess whether novel processes that utilize combinations of control measures provide a level of protection equivalent to traditional processing methods. For industry, this risk-based process development approach provides a roadmap for safe innovation and will encourage the development of innovative technologies. For academia, many opportunities exist to make great contributions to the success of risk-based process development through development of innovative process technologies, mathematical modeling, and for fundamental research in preservation-based multiple-hurdle preservation.

**For further information:**

The U.S. Department of Agriculture (USDA) over the past 25 years has become increasingly involved in developing new biofuels such as cellulosic ethanol, biobutanol, and renewable diesel fuel as a way to benefit farmers, the biofuels industry, and the public at large by using agricultural and other feedstocks. USDA Agricultural Research Service (ARS) laboratories are located in diverse biogeographic regions throughout the country and are geared toward producing sustainable, efficient, and economical energy from these feedstocks. ARS’s primary research thrusts include: 1) enabling the continued growth in commercial ethanol and biodiesel, 2) developing new biochemical conversion processes to utilize additional feedstocks to produce fuel ethanol and other fuels such as biobutanol outside the Midwestern Corn Belt, and 3) pursuing thermochemical processes including gasification and pyrolysis to convert biomass and crop residues to syngas and biooil. The USDA Cooperative State Research, Education, and Extension Service (CSREES) also funds bioenergy research at land grant and other universities and administers the Small Business Innovation Research (SBIR) program.

Making commercial biofuels cost-competitive

The production of ethanol and biodiesel has expanded significantly over the past several years. Despite the success of these technologies, their relatively high cost remains an issue. Research is underway at ARS’s Crop Conversion Science and Engineering Research Unit at the Eastern Regional Research Center (ERRC) to lower the cost of fuel ethanol production from corn by developing new microbes and enzymes. For example, novel enzymes have been identified that enable a “no cook” low-temperature process (Stargen™) that can digest raw, uncooked starch granules. ERRC researchers developed this more efficient process in collaboration with Genencor International. Less energy is used and more starch is converted to fuel ethanol, thus squeezing more ethanol out of a bushel of corn.

Conventional biodiesel production technologies are well established and work very well if the feedstocks are limited to high-quality lipid (fat soluble) materials such as soybean oil. However, many of the processes have shortcomings if lower quality and lower cost feedstocks are used, such as yellow and brown greases. A USDA SBIR grant supported research by Resodyn, based in Butte, Mont., led to the development of a proprietary process that maximizes the yields of multiple feedstocks (both low and high quality), resulting in some of the lowest production costs in the industry. Today, new biodiesel plants across the country are using the technology developed by Resodyn. In the future, new in situ transesterification technologies being developed by ERRC may reduce costs further by allowing biodiesel to be produced from lower quality lipids such as distiller dried grains with solubles (DDGS) and meat and bone meal. This could add 1.135 million L (300 million gal) a year to the biodiesel supply. U.S. biodiesel production in 2007 was estimated at 1.703 million L (450 million gal).
Alternative feedstocks and production technologies

Most ethanol biorefineries are located in the Corn Belt far from most of the country’s largest cities. For corn-based ethanol, transportation costs are a significant expense, considering that the product must be shipped hundreds of miles to meet the energy needs of urban populations. In addition, there is growing concern regarding the allocation of sufficient corn for all food, fuel, and feed uses. As a result, research is being conducted on region-specific conversion processes that can utilize crops, such as barley, that can be produced outside the Corn Belt.

New barley varieties could lead to billions of gallons of fuel ethanol production, help to mitigate growing demands on corn supplies, provide significant revenue to growers outside the Corn Belt, and serve as a winter cover crop to reduce erosion. Two new low-energy, high-yield production procedures being developed at ARS Crop Conversion Center represent a quantum leap in energy and production efficiency of ethanol from barley; an enhanced dry grind enzymatic ethanol process and a granular starch hydrolyzing enzyme ethanol process using state-of-the-art low-temperature starch-converting enzymes are being developed.

Work is also underway to turn vast reserves of cellulosic material such as corn fiber, switchgrass and other perennial grasses, and wood chips into five- and six-carbon sugars that can be fermented into biofuels. The problem is that this cellulosic material—millions of tons of it—does not chemically break down like easily fermentable corn. Work is being undertaken on how to deconstruct plant cell walls through biochemical conversion processes. The biochemical route uses enzymes and/or microorganisms to break down complex carbohydrates in the biomass. Then, yeast metabolizes the simple sugars to make alcohol. Many processes are being used to convert cellulosic material into ethanol, but many are costly and require large amounts of energy for the conversion
process. ARS is working on ways to bring down the cost of producing cellulosic ethanol through the collaboration of its plant and conversion scientists and engineers in developing new crop varieties such as switchgrass, alfalfa, and reed canary grass that are better suited for bioconversion to fuel ethanol.

In addition to ethanol, the USDA is also examining the production of other fuels, such as butanol, with considerable promise due to similarity to ethanol but with higher energy content like gasoline. ARS National Center for Agricultural Utilization Research is perfecting an energy-efficient process for converting wheat straw to biobutanol, which is part of a larger project designated “Cost-Effective Bioprocess Technologies for Production of Biofuels from Lignocellulosic Biomass.” In the private sector, global energy company BP and science innovator DuPont recently partnered in order to bring biobutanol to the marketplace.

**Pyrolysis and gasification are part of the solution**

Researchers are also examining thermochemical conversion as an alternative to the biochemical option for obtaining liquid fuels and energy from cellulosic biomass. Unlike biochemical options that rely on living, and sometimes very sensitive, biological systems, thermochemical conversion uses engineered chemical systems to directly or indirectly convert biomass to liquid fuels by gasification or pyrolytic reactions. This alternative may produce lower-cost biofuels than biochemical processes for producing cellulosic ethanol. For example, the optimal size of advanced cellulosic biofuel plants using biochemical pathways is expected to be three to five times that of existing grain-to-ethanol plants. In contrast, thermochemical processes can produce biomass-based hydrocarbon fuels at high temperatures, which allows for faster conversion in smaller reactors. As a result, smaller facilities could be built with lower capital costs and could even be located on farms or in local areas. This is important because agricultural residues are generally widely distributed across the landscape, and their transport to large, centralized conversion facilities is, in many cases, prohibitively expensive. Additionally, the amount of water needed for processing hydrocarbon fuels from biomass can be greatly reduced compared with the dilute sugar solutions required by enzymes.

Canadian firms Dynamotive and Ensyn both were the first to produce pyrolysis oil, also known as bio-oil, commercially. Bio-oil is currently used in turbines and boilers, but it can be upgraded to diesel-like fuels and could be made into a transportation fuel in the future. The U.S. Department of Energy (DOE) is providing $7 million in funding for additional bio-oil research. The USDA is particularly interested in the possibility of placing pyrolyzer units close to biomass sources at the farm or production level. The high density of bio-oil is expected to result in lower transportation costs compared to chopped or baled biomass, allowing it to be transported longer distances at a reduced cost.

On-farm gasification is being examined by ARS’s Corvallis research station in the Pacific Northwest. Biomass can be converted to syngas, which can then be converted to a gasoline-like product. A public-private partnership was formed between the ARS, Farm Power, Inc. (a non-profit group from Spokane County, Wash.), Inland Power and Light, Bonneville Power Administration, the DOE, and the USDA Rural Development to develop a scalable gasification system to convert straw into biopower, and eventually, liquid fuels for on-farm use. Straw gasification with residues collected during the seed harvest began in mid-summer 2008.

**The “big idea”**

The “big idea” focuses on flexibility in inputs and in bioenergy outputs. This is the driving force behind the ARS Western Regional Research Center’s (Albany, Calif.) municipal solid waste-to-ethanol integrated biorefinery. Various portions of the waste stream including clean paper fiber would be turned into ethanol. Organic wastes would be “digested” in an anaerobic digester that produces methane gas. The remaining waste stream (lignin, plastics, inks, and oils) will be sent to a gasifier to produce syngas. These gases would then be used in a gas turbine to generate electricity for production requirements, with excess power being sold to the grid. This would also help to solve a waste disposal problem, as landfill space is becoming scarcer. This project is under serious consideration for scale-up from the concept-

**The corn stover being evaluated by USDA soil scientist Jane Johnson is a potential feedstock for gasification and cellulosic ethanol production. (Photo by Kathy Eystad, courtesy USDA-ARS)**
al model in a partnership with the Salinas Valley (Calif.) Solid Waste Authority.

General Motors and renewable energy biology firm Coskata, Inc., recently announced a new project to link thermochemical and biological conversion in order to optimize ethanol production from biomass. CSREES supported the initial research on gasification-syngas fermentation research at Oklahoma State University (OSU), and the technical details were featured in Resource (April 2008). The economics look promising (less than U.S. $1 per gal). Another benefit (according to Coskata) is that less than one gallon of fresh water is used per gallon of ethanol produced. Traditional corn-based systems typically use three to four gallons of fresh water per gallon of ethanol produced, and enzymatic approaches can use as much as seven gallons of fresh water per gallon of ethanol produced. According to an independent study conducted by DOE’s Argonne National Laboratory, Coskata’s process—using the microorganisms developed by the USDA/OSU collaboration—can reduce carbon dioxide emissions by as much as 84 percent compared to conventional gasoline.

For further information:

Bioenergy & Energy Alternatives:


CSREES bioenergy and other energy research: webdev.csrees.usda.gov/newsroom/briefs/renewable_energy.html


A need to back all horses

Many exciting developments are occurring in the field of biofuel development that promise to push the frontiers of many disciplines in the quest for cleaner liquid fuels. A number of options are being pursued to make the production of current commercial fuels, such as ethanol and biodiesel, more economical and to advance biofuel production from cellulosic sources. Biological and thermal technologies each have advantages and disadvantages when compared to each other. Public and private sponsored research is angling to maximize the advantages of each process, and in some cases, combine their best attributes. The bottom line is that we need to hedge our bets and pursue all of these approaches, as there is currently no silver bullet technology that will solve all of our energy requirements. Sustained public and private investment will be needed to realize the promise of liquid fuels and allow their expanded commercialization in the future.

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Winston Churchill described Uganda as the pearl of Africa; however, many of us remember the country more for the brutal regime of Idi Amin. Uganda has 30 million people yet is the size of Oregon (population 3.7 million). Our recent trip to this nation, which straddles the equator, was a transformative experience as the vivid memories of the lush countryside and soft-spoken people linger in my mind.

A unique characteristic of Africa stares out from a map. Unlike other continents, the national borders consist mainly of straight lines rather than contours that follow natural geography. At the Berlin Conference of 1885, European powers carved Africa into their colonies. The consequences of colonization and struggles for effective self-rule still linger.

My family traveled to Uganda with the Center for Sustainable Rural Livelihoods (CSRL) of Iowa State University. The Center originated from a couple’s generous gift for utilizing the university’s expertise in applying sustainable solutions for overcoming poverty and hunger. A worldwide search determined that the most significant impact could be made in Uganda by partnering with a local development group (VEDCO) and Makerere University, one of the oldest (founded 1922) and most prestigious universities in Africa, with 33,000 students.

Challenges facing Sub-Saharan Africa are legion

Two competing visions exist on how the problems can be overcome. A top-down theory of central planning with huge amounts of foreign aid is advocated by Jeffrey Sachs in *The End of Poverty* and exemplified by the United Nations Millennium Project. The premise is that the world’s poor are caught in a “poverty trap” from which Western planners must rescue them. The antithesis is described in *The White Man’s Burden*. The title comes from a Rudyard Kipling poem, but the subtitle summarizes the book: *Why the West’s Efforts to Aid the Rest Have Done So Much Ill and So Little Good*. It advocates small programs run by native “searchers” using small, specific projects. The author, William Easterly, is a development economist who became disillusioned with the central planning process. The Iowa State project follows this latter approach.
CRSL partnership means progress

The CRSL partnership serves 800 households with 7500 people. In 2005, only 9 percent of the people had food security (two meals per day). Today, after educating people to grow more nutritious crops and improve eating habits, food security has grown to 90 percent!

Our daughter Elizabeth was part of the Ugandan school project where Iowa State students cleared jungle growth with a machete (which made slash and burn seem quite attractive!), expanded the school garden, and taught agricultural classes. In Uganda, making children work in the garden is often considered a punishment—some things are universal—so having white Americans gardening encouraged the children to literally dig in, both at school and at home. Planting gardens allows schools to provide nutritious lunches to students, which may be the only food they get in a day. This food security entices more children, especially girls, to attend school and stay in school longer.

A land grant university in Africa?

Some may question the role of a land grant university in Africa. However, its assistance is reminiscent of extension work done a century ago in the U.S. Midwest. Local leaders and “searchers,” frequently women, are provided education, seeds, and plant cuttings. One woman shared 80 banana plants with 19 others and now has two acres of bananas herself. Another owner was raising hogs and was very proud of her record litter of 15. Microfinancing is also used, and applicants can borrow U.S. $300 for expanding their business. Repayment of these loans is at 100 percent. Excitement radiates from Ugandan people due to their newfound successes.

“Mzungu!”

A special delight in Uganda are the children. They jump up and down, point and squeal “Mzungu!” (white people)—similar to what we did when we saw a zebra or hippopotamus. Children run out to grasp hands and take a walk. Their spontaneity and warmth stole our hearts.

The most sobering moment of our journey occurred while visiting a mother with a severely malnourished child. Her two previous children had died, and she seemed resigned to losing her third. Both she and the child are HIV positive. However, with intervention and better nourishment, the child and mother have since improved. Unfortunately, the medical clinics treat conditions with medicine rather than with nutritional education that could improve eating habits and long-term health.

While in Kampala I met with Dr. Levi Kasisira, head of the agricultural engineering department at Makerere University. We discussed how engineering can be utilized in Uganda. One example: walking tractors (large roto-tillers) that come from China, but the challenge is sustainability.

There was great excitement whenever “Mzungu” arrived.
I did not fully grasp the lack of mechanization until our host saw an ox plow. She exclaimed that we should take a picture of this unusual sight; otherwise we saw only people with hoes.

Amidst the extreme poverty in the countryside, where 85 percent of the people live, we marveled at the bright, colorful clothing and the use of cell phones. Numerous old buildings painted hot pink provide the advertising for the local phone company.

**Precious H₂O**

Water is the gift of life, and Ugandans walk miles for it. During our travels, we learned that a school was to be the recipient of a borehole (well), and children were thrilled to witness the drilling. One of the most moving moments of my life was the commissioning of a borehole that our family had donated. A crowd of villagers dressed in their finest, greeted us with dancing, songs, cheering, and speeches that are forever etched in our memories.

Also assisting were students of Engineers for a Sustainable World. They had built a rain collection system and cistern to collect water during the rainy season and a biogas digester that provided gas for cooking and lighting. It was exciting to see engineering designs that were suitable for this area.

**If you can—go, and make a difference**

A visit to the Pearl of Africa is transforming. The spirit of her people in the midst of extreme poverty reminds us that material wealth is not a requirement for inner joy. And, as Ghandi said, there is opportunity to “Be the change you want to see in the world.”

**ASABE Past President Charles Sukup** is president of Sukup Manufacturing Co., Sheffield, Iowa, USA, charles@sukup.com.
Agricultural and biological engineers, and the value they contribute to our society, are more important today than ever before. Witness the events of just the past year—record-level prices for commodities, such as wheat, soybeans, and corn; gasoline prices threatening to push past the heretofore unconscionable level of U.S. $4 a gallon; and devastating flooding throughout the Midwestern states. These events serve to clarify how critically important the continued efficiency and productivity of America’s heartland is to our standard of living and to our ability to become energy independent. Agricultural and biological engineers will certainly be at the forefront of the issues on everyone’s minds these days. The knowledge, skills, and abilities they bring to the table will be put to the test by a world more hungry for the simple luxuries (such as a diet rich in better-quality grains and animal-based proteins) that many affluent nations take for granted.

Willing to learn and expand networks

To be sure, agricultural and biological engineers must be willing to learn more, to learn from different, perhaps unusual, sources, and expand their network of personal and professional contacts available to assist in problem-solving. While the knowledge available from traditional, structured, and more formal sources, such as college or university courses, company-sponsored instruction, and various governmental entities, can be useful and has its place, it is not a useful substitute for the loosely structured, almost transparent groups that often exist across traditional boundaries. Not formally linked by any company org chart and not bearing any direct responsibility to one another, these informal, organic groups of individuals nonetheless are able to spread knowledge and innovation by recognizing some aspect of work that creates a common bond or interest. These groups, known as communities of practice, have been the conduit for a great deal of engineers’ on-the-job training for decades, even though the term itself was not coined until 1991 (by Etienne Wenger and Jane Lave in *Situated Learning: Legitimate Peripheral Participation*).

Communities of practice have masters—members who possess an informally acknowledged superior level of knowledge and expertise; apprentices—the less experienced members; and those who fall somewhere in between. All members benefit from their association, but in different ways. Apprentices benefit by accessing knowledge that is frequently stealthy, tacit, nuanced, and “sticky” (difficult to formally codify or describe) and often bridges the gap between classroom theory and real-world practice. Masters benefit by teaching others, enjoying a certain degree of prestige through an informally recognized “guru” status, and they continue their own learning process through an association with others and their novel and unusual experiences and problem-solving.
capabilities. And everyone benefits by expanding and strengthening their network of both personal and professional contacts, even those unrelated to the community of practice that has enabled the relationship and association. The sense of purpose, relevance, and socialization common among members is the glue that holds the community of practice together, however and whenever they choose to meet.

**Advantages of association**

Agricultural and biological engineers stand to benefit richly from an association with a community of practice, primarily because communities of practice are populated by individuals who recognize the mutual benefit of associating with one another, regardless of where they may be positioned on a company org chart. For example, a community of practice may be centered around a pervasive problem that includes people who frequently compare notes on an informal basis. By doing so, they not only move closer to a solution that will benefit a large number of members, but also increase their personal knowledge bases, skill sets, and networks of both business and personal contacts during the process. Additionally, an engineer who is engaged in such a community of practice, who has the ability to absorb innovative engineering practices from peers, and who can recognize their applicability in subsequent situations, is likely to be more employable as well.

Despite the advantages offered by communities of practice, these benefits can easily be eroded by organizations that inappropriately attempt to capture the value they provide. The collaborative relationship that develops among community of practice members cannot be forced or implemented by management. Because a community of practice is a naturally occurring, informal, organic group of individuals whose association fills a gap that frequently exists in organizations, such groups perform best when management simply steps back and allows them to perform the activities that members, and not managers, decide to do.

Paradoxically, the formal acknowledgement of the contribution made by a community of practice can inadvertently lead to its demise. Why? Because managers, in an attempt to co-opt an untapped resource may inappropriately reward the community of practice by assigning more formally defined work, which tends to include objectives, deadlines, and other metrics that quantify value in more financially appealing terms. This can be anathema, as the common bond or interest shared by community of practice members is trumped by the motive of harvesting increased profits. When the results are less than stellar, management is left to wonder what went wrong. This conundrum is best summed up by Peter Hillen, a partner with Congruity Corp., a consulting firm in Los Altos, Calif., who states, “The community of practice needs to do the work it thinks it needs to do, not the work some guy in a suit tells it to do.”

Communities of practice provide a unique and valuable resource, although not according to the rules of conventional business practices. To better enable their formation and growth, managers need to step back and not meddle—a difficult task in itself.

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**Common Characteristics of Communities of Practice**

- Continuity of mutual relationships – may be either collegial or strained.
- Rapid flow of information between community members (very fluid grapevine).
- Conversations and other interactions often feel as if they are being continued from where they stopped.
- Problems and other issues are framed quickly, little necessity for providing an extensive background.
- Common consensus regarding membership and who belongs. Barriers to membership are minimal and informal.
- Awareness of others’ competencies, strengths, weaknesses, and where one’s contributions can be maximized.
- Common stories, legends, inside jokes, humor, etc.
- A shared and evolving language, including jargon, acronyms, and unique terminology. Language shortcuts often evolve to increase communication efficiency.
- Common perception, viewpoint or vantage point of relevant external environment. Viewpoint is frequently localized or parochial.

In Brief: In a semester-long project, middle school students from across the United States use engineering principles to design and build cities of the future with a focus on self-sufficient water systems. Regional competition winners travel to Washington, D.C., to vie for the grand prize: a week at Space Camp.

Nobody can doubt the importance of water and water resources in our world, whether it’s clean drinking water or water as a resource for sanitation, irrigation, or fire protection. But as our cities grow and expand, what can be done to conserve and reuse such a valuable resource? Beginning last fall, thousands of middle school students began to tackle that question in the 2009 National Engineers Week Future City Competition™.

Sponsored by the nation’s professional engineering community, Future City aims to ignite interest in science, technology, math, and engineering among young people. Students work in teams under the guidance of a teacher and a volunteer engineer mentor to design and build a city of tomorrow. They must also conduct research for an essay on a pressing social need. This year, the essay centers on ways to improve water use by creating a home system that minimizes the use of municipal or externally supplied water for a household’s daily requirements.

Future City Competition will be held throughout this month in 40 regions across the country. First-place winners from each qualifying regional competition receive an all-expense-paid trip to the 17th annual Future City National Finals in Washington, D.C., Feb. 16-18, during National Engineers Week. The national grand prize is a trip to U.S. Space Camp in Huntsville, Ala.

Hundreds of thousands of young people have been introduced to engineering, many for the first time, through Future City Competition. Now in its 18th year, the competition makes engineering come alive and has been credited with guiding many students to consider engineering careers. Critical to that success are the volunteer engineer mentors, who serve as role models for young minds eager to learn.

Think of it as 30,000 eager students in search of an engineer—and perhaps an engineering career.

Each year, tens of thousands of seventh and eighth graders work with a volunteer engineer mentor, who guides students through the complicated realities of creating a future community with a complete, functioning infrastructure, from skyscrapers and parks to transportation and energy.

Along the way, students discover the role of engineering in their own lives, and their potential to take on that role themselves.

The benefit for the students—and the engineering profession— is obvious, but engineers who have yet to experience Future City firsthand may want to know what’s in it for them. To hear veteran mentors tell it, the simple answer is: plenty.

“We get the privilege of opening doors to new worlds and possibilities for them, and in return they help to inspire us and rekindle our own passion for engineering and future solutions to problems we face today,” explains Catherine Anderson, engineer mentor at Queen of Angels Catholic School in Roswell, Ga.

Ted Beidler, mentor to Heritage Middle School in Westerville, Ohio, agrees. “I work for the government as a county engineer,” says Beidler, “but I suspect our desires are the same as a private entity: attracting smart, personable individuals to the profession. If we can show some young person the rewarding opportunities that an engineering career can offer, all the better for our profession.”

Julie Gennaro, a consulting engineer at URS who guided the Future City team at Our Lady Help of Christians school in Abington, Penn., says the time investment is well worth it.

“We all know the statistics about the lack of students entering the engineering profession,” says Gennaro. “Well, here is an
opportunity to do something about it and inspire young people to pursue engineering as a profession. Some students never even considered engineering before participating in Future City.”

Gennaro also notes that those who volunteer find Future City a natural fit. “As engineers we love to solve problems,” she says. “What can be more fun than spending time with a group of young people discussing current and future engineering challenges and brainstorming solutions?”

ASABE is the sponsor of a special award for the Future City Competition national finals. The award is unique among the many special prizes in that it is the only one that rewards teams for giving critical attention to one of society’s most basic needs—food. The ASABE award, Most Sustainable Food Production System, will recognize the design “that provides the best sustainable food production system while conserving soil, water, and energy.” The three members of the winning team will each receive $100.

For more information contact Bill Knight, bknight@futurecity.org.

**Retooled approach may make bio-based butanol more competitive with ethanol**

**In Brief:** ARS researchers have modified a method of producing biobutanol that could make the fuel more competitive with ethanol as a clean-burning alternative to gasoline.

According to Agricultural Research Service (ARS) chemical engineer Nasib Qureshi, biobutanol offers several advantages. It can be transported in existing pipelines, it’s less corrosive, it can be mixed with gasoline or used alone in internal combustion engines, and it packs more energy per gallon than ethanol.

Until the mid-20th century, biobutanol was produced from fermented sugars such as corn glucose. But low yields, high recovery costs, and petroleum’s increased availability after World War II sidelined fermentation-based systems for biobutanol production.

Today, petroleum price increases have rekindled interest in tapping butanol as a biobased fuel, notes Qureshi, with the ARS National Center for Agricultural Utilization Research in Peoria, Ill. In 2003, he began researching the use of wheat straw to make biobutanol—drawn by the straw’s abundance and promise as a lower-cost alternative to corn-glucose-based feedstocks.

Like other biobutanol processes, his approach employed *Clostridium* bacteria to carry out the critical task of fermentation. Such processes normally involve four preparatory steps (pretreatment, hydrolysis, fermentation, and recovery) carried out separately and sequentially. But Qureshi and colleagues devised a way to combine three of the four steps. For example, enzymes and the bacteria are allowed to carry out their respective tasks simultaneously. Throughout, a procedure known as “gas stripping” is used to extract the biobutanol as it is produced.

In early trials, the method increased biobutanol productivity by twofold above traditional glucose-based fermentation. A later adjustment, dubbed “fed-batch feeding,” increased production even further. For example, during a 22-day fed-batch operating period, a culture of *C. beijerinckii* P260 converted nearly 430 grams of sugar into 192 combined grams of acetone, biobutanol, and ethanol.

If scaled up further, the process could yield 99 gallons of these three chemicals from one ton of wheat straw.

For more information contact USDA-ARS public affairs specialist Jan Suszkiw, Jan.Suszkiw@ars.usda.gov.

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**About the National Engineers Week Foundation**

The National Engineers Week Foundation, a formal coalition of more than 75 professional societies, major corporations and government agencies, is dedicated to ensuring a diverse and well-educated future engineering workforce by increasing understanding of and interest in engineering and technology careers among young students and by promoting pre-college literacy in math and science. Engineers Week also raises public understanding and appreciation of engineers’ contributions to society. Founded in 1951, it is among the oldest of America’s professional outreach efforts. Chairs for 2009 are Intel and the National Society of Professional Engineers. For more information, visit www.eweek.org.
**In Brief:** A team led by a Montana State University professor has found a fungus that produces a new type of diesel fuel, which holds great promise as an alternative to fossil fuels and is at its earliest stage of development.

Calling the fungus’ output “myco-diesel,” Gary Strobel, MSU professor of plant sciences and plant pathology, says the find is even bigger than his 1993 discovery of fungus that contained the anticancer drug taxol. Strobel, who travels the world looking for exotic plants that may contain beneficial microbes, found the diesel-producing fungus in a Patagonia rain forest. Strobel visited the rain forest in 2002 and collected a variety of specimens, including the branches from an ancient family of trees known as “ulmo.” When he and his collaborators examined the branches, they found fungus growing inside. They continued to investigate and discovered that the fungus, called *Gliocladium roseum*, was producing gases. Further testing showed that the fungus—under limited oxygen—was producing a number of compounds normally associated with diesel fuel, which is obtained from crude oil.

“These are the first organisms that have been found that make many of the ingredients of diesel,” Strobel said. “This is a major discovery.”

Strobel doesn’t know when drivers will fill their gas tanks with fungi fuel or if processors can make enough to fill the demand. The road to commercialization is filled with potential glitches, he said. It’s also a major endeavor that will be left to others who specialize in those areas.

Myco-diesel could be an option for those who want alternatives even to ethanol, however, Strobel said. Some car manufacturers who shun ethanol might consider myco-diesel or fuels produced by other microbes.

“The question is, are there other microbes out there that can do that for us?” he asked.

Researchers in government agencies and private industry have already shown interest in the fungi. A team has been established to conduct further research at MSU’s College of Engineering and Yale University. One member of the team is Strobel’s son, Scott, who is chairman of molecular biophysics and biochemistry at Yale and a Howard Hughes Medical Institute Professor. The MSU-Yale team will investigate a variety of questions, including the genetic makeup of *Gliocladium roseum*.

“The main value of this discovery may not be the organism itself but the genes responsible for the production of these gases,” Gary Strobel said. “There are certain enzymes that are responsible for the conversion of substrates such as cellulose to myco-diesel.”

Scott Strobel said his team is already screening the fungus’ genome. Besides determining the complete genetic makeup of the fungus, they will run a series of genetic and biochemical tests to identify the genes responsible for its diesel-making properties.

“The broader question is, what is responsible for the production of these compounds,” Scott Strobel said. “If you can identify that, you can hopefully scale it up so you end up with better efficiency of production.”

“There’s nothing in the scientific literature about a microbe that produces the diversity of medium-chain hydrocarbons found in the *Gliocladium roseum*,” he said. Longer hydrocarbon chains are common, but “that’s not what you put in your gas tank or jet engine.”

Another promising aspect is that the fungus can grow in cellulose. “That’s the most common organic molecule on earth,” Scott Strobel said. “It’s all around us, everywhere.”

 Scientists in a variety of disciplines should be able to work together to optimize production and find a way to turn what is essentially a vapor into a burnable liquid fuel, he added.

For more information contact Evelyn Boswell, MSU News Service, evelynb@montana.edu.
Scientists model the scaling laws of water uptake by plant roots

In Brief: With changes in climate, farmers and ranchers must contend with diminishing water resources. One of the best ways to deal with this challenge is to maximize the efficiency of plant root systems, and researchers in North Dakota are taking steps to do just that.

With funding from USDA’s Cooperative State Research, Education, and Extension Service (CSREES) National Research Initiative (NRI), Mario Biondini at North Dakota State University found a way to more accurately predict water uptake from plant roots by improving upon the West, Brown, and Enquist (WBE) general model for scaling laws in biological networks.

Researchers use models extensively to test various agricultural research questions and natural resource management problems, such as soil quality, water and nutrient requirements, and climate change.

The WBE model uses the geometry of network systems for resource exchange to predict the chemical reactions required for life-sustaining functions in biological organisms. This model has been used in plant vascular systems to model the movement of water and nutrients in the xylem and phloem, the two types of transport tissue in the aboveground parts of plants.

The WBE model was designed for closed systems, where materials are exchanged only at the tip of the network. Therefore, the WBE is not the ideal model for predicting water uptake in open systems, such as the root systems of plants, where water can be exchanged throughout the entire network.

Maximizing water uptake in plant roots requires balancing two types of flow throughout the network. The first involves minimizing the resistance to flow inside the network, the longitudinal flow. The other involves maximizing water flow into the network, the transversal flow. Mathematically, the longitudinal flow is inversely proportional to the fourth power of the root radius, while the transversal flow is inversely related to the radius of the root.

Biondini modeled the optimal root radius for water uptake and transfer for any arbitrary volume and branching configuration. Model results were tested with data collected from 1,759 plants belonging to 77 herbaceous plant species. Other parameters considered in the model included soil type and drainage.

Results suggested that the root scaling configuration that maximizes water uptake is independent of water demand or soil/water distribution.

In the model, Biondini used a simplified version of a root system that still captured the flow dynamics of the entire network.

Plant diversity and the sustainability of managed ecosystems are, in part, highly dependent on the volume of soil explored by root systems and the density and distribution of those root surfaces. Accurate modeling of root systems and their nutrient and water uptake, thus, is an essential tool for the planning and implementation of modern agro-ecosystem practices.

For more information contact Stacy Kish or Jennifer Martin, CSREES, (202) 720-8188.
Adding value to biofuel waste

In Brief: Ramon Gonzalez, the William W. Akers Assistant Professor in Chemical and Biomolecular Engineering, and Syed Shams Yazdani, postdoctoral research associate, Rice University, have identified the metabolic processes and conditions that allow a known strain of E. coli to convert glycerin into ethanol.

What do you get when you cross E. coli with biofuel waste products? A new process that may revolutionize the economic development of the growing biofuel industry.

Biofuels represent the best sustainable, secure, and renewable alternative to fossil fuels. Unfortunately, biofuel production is beset by the same problem as traditional petroleum refining – excess waste. In traditional refining, only about 60 percent of the crude oil becomes gasoline, the rest is used to make other products. Similarly, as biofuel production increases, the market is being flooded with its waste byproducts, specifically glycerin, also known as glycerol.

Glycerin is cheap and abundant in the current marketplace. Although there are many potential uses for the substance, it is difficult to break it down into products with greater economic value.

With funding from USDA’s Cooperative State Research, Education, and Extension Service (CSREES), Ramon Gonzalez at Rice University developed a new fermentation process that uses E. coli to convert glycerin into high-value chemicals, like succinate.

Succinate and its derivatives have an annual domestic market of more than $1.3 billion. Succinate is used in a variety of products including as a flavoring agent in food and beverages, an intermediate compound for dyes and perfumes, and in medical applications. Another product, formate, is principally used as a preservative and antibacterial agent in livestock feed.

Most of the waste glycerin comes from the production of biodiesel, one of the two types of biofuels (the other being ethanol). Biodiesel is converted from a variety of oils, including rapeseed and soybean oils, mustard, flax, sunflower, and palm oil, waste vegetable oil, animal fat oil, and algae.

About 0.5 kg (1 lb) of glycerin is produced for every 5 kg (10 lb) of biodiesel. According to the National Biodiesel Board, U.S. companies produced about 1,703 million L (450 million gal) of biodiesel in 2007. With 60 new plants capable of producing 4.5 billion L (1.2 billion gal) of biofuel slated for operation by 2010, an answer to the glycerin question cannot come soon enough.

“Biodiesel producers used to sell their leftover glycerin, but the rapid increase in biodiesel production has left them paying to get rid of it,” Gonzalez said. “The new metabolic pathways we have uncovered pave the way for the development of new technologies to convert this waste product into high-value chemicals.”

Technologies based on Gonzalez’s work have been licensed to Glycos Biotechnologies, Inc., a Houston-based startup company that plans to open its first demonstration facility within the next 10 months.

The research team is now working to further understand the biochemical pathways used by the organism to break down the glycerol so that new organisms can be engineered for the production of fuels and other chemicals from glycerol.

“Our goal goes beyond using this discovery for a single process,” Gonzalez said. “We want to use the technology as a platform for the ‘green’ production of a whole range of high-value products.”

For more information contact Stacy Kish or Jennifer Martin, CSREES, (202) 720-8188.
PROFESSIONAL OPPORTUNITIES

Resource is published eight times per year: January/February, March, April/May, June, July/August, September, October/November, and December. The deadline for ad copy to be received at ASABE is four weeks before the issue’s publishing date.

Advertisements are $125 per column-inch length (column width is 3.5 inches) and include free placement on the ASABE Career Center at www.asabe.org/membership/careercenter.htm. The minimum ad size is two inches — approximately 100 words — to qualify for the free online listing. Ads are posted on the Web site within three business days of final approval and remain there for 30 days. If the insertion order is for two months, the cost is $110 per column inch per insertion and includes a 60-day free Web listing.

For more details on this service, contact Melissa Miller, ASABE Professional Opportunities, 2950 Niles Road, St. Joseph, MI 49085-9659, USA; 269-429-0300 ext. 317, fax 269-429-3852, miller@asabe.org, or visit www.asabe.org/resource/persads.html.

ASSISTANT/ASSOCIATE PROFESSOR FOOD PROCESSING AND ENGINEERING AGRICULTURAL RESEARCH STATION SCHOOL OF AGRICulture

Position Number: FO600 (Twelve-month appointment)
Salary Range: Commensurate with education and experience
Appointment Date: Until filled

Duties and Responsibilities: Develops basic and applied research programs in the areas of food processing and engineering leading to technology transfer, peer reviewed publications and extramural funding. Research areas include emerging processing techniques, packaging materials and methods, and physical properties of foods. Interfaces and collaborates with existing food science programs and related industries. Enhances the University’s land-grant mission of teaching, research and extension by assisting in the development and implementation of a comprehensive food science program. Participates in state, regional, and national scientific meetings and professional societies. Participates in departmental, school and university services and outreach activities.

Qualifications: Ph.D. degree in Food Science/Engineering or closely related discipline. Must have research experience in current practices of processing techniques and the effects of processing parameters on product quality. Must have teaching experience in mass and energy balances for a given food process and the unit operations required to produce food products. Must have a desire to build effective collaborations with existing research and teaching programs. Highly effective written and oral communication, and computer skills are essential. Scholarly publications and grantsmanship are a must. Experience and knowledge in food transportation, preservation, sanitation, and waste management are desired.

Special Instructions to Applicants: Virginia State University will accept applications through the on-line Recruitment Management System (RMS) at http://jobs.agencies.virginia.gov (Agency 234 – Cooperative Extension and Agriculture Research Services). Interested persons must attach a letter of interest, a current resume/vita, and the names, addresses, telephone numbers, and e-mail addresses (if available) of three professional references. Transcripts and three (3) letters of references must be attached to online application or mailed to: Office of Human Resources, Virginia State University, 1 Hayden Drive, Box 9412, Petersburg, Virginia 23806-9412.

Your name and the position number (FO600) must be clearly identifiable on each item submitted. Official transcripts and three (3) letters of reference will be required prior to employment. Screening of applications will commence immediately, although applications will continue to be accepted until the position is filled.

Selected candidate must pass a criminal background check, including fingerprinting and must complete a Statement of Personal Economic Interests as a condition of employment, if applicable.

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TENURE-TRACK POSITION IN FOOD PROCESS ENGINEERING

Department of Nutrition and Food Science
Department of Biological and Agricultural Engineering

Texas A&M University seeks candidates for a 9-month, tenure-track position at the Assistant Professor level in the area of Food Process Engineering. The position is a dual appointment between Department of Nutrition and Food Science http://nfsctamu.edu (60%) and Department of Biological and Agricultural Engineering http://baen.tamu.edu (40%) in the College of Agriculture and Life Sciences. The candidate will develop an integrated research and teaching program in food process engineering, packaging, functional biopolymers and/or biochemical engineering to understand the impact of processes on structural-functional changes and food ingredients. The candidate will teach at the undergraduate and graduate level, establish a publication record, and attract extramural funding. The successful candidate should have the desire to participate in multidisciplinary research program focused on the impact of food science and nutrition.

The position requires a Ph.D. in food science, chemistry, microbiology, food engineering, or related engineering field and requires a Professional Engineer (P.E.) license or qualifications for registration in Texas. The potential for research productivity, grantsmanship, and teaching should be apparent. Queries should be directed to Dr. Steve Talcott (stalcott@tamu.edu) (979-862-4056), chair of the search committee. Applicants should submit: 1) a letter of application, 2) curriculum vitae, 3) description of teaching and research goals, and 4) arrange for three letters of recommendation addressing: 1) teaching ability, 2) research creativity and grant-writing experience, and 3) interpersonal and team-building skills. Send applications via email to Dr. J Jimmy T. Keeton, Interim Department Head, Department of Nutrition and Food Science, 2253 TAMU, Texas A&M University, College Station, TX 77843-2253 at g-hyden@tamu.edu. Review of applications will begin June 1, 2009 and continue until the position is filled.

The Texas A&M University is an equal opportunity employer.
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Tenure-track position to conduct research on thermochemical processes that convert biological materials to value-added products, with initial focus in gasification of a variety of biomass feedstocks to generate synthesis gases that are fermented into liquid fuel and co-products. Requires earned doctorate in Biosystems, Agricultural, Chemical, or Mechanical Engineering or closely related engineering discipline.

Detailed job descriptions for these and other vacancies may be found at http://biosystems.okstate.edu. Both positions are full-time, 11-month faculty appointments. Salary commensurate with qualifications.

Apply immediately as screening of applications begins in January and will continue until suitable candidates are found. Applications consisting of a letter of interest, vita, academic transcripts and contact information for three references should be submitted to: Dr. Ronald Elliott, Department Head and Professor, Faculty Search – (insert position title), Biosystems & Agricultural Engineering, OSU, 111 Agricultural Hall, Stillwater, OK 74078-6016, Fax: (405) 744-6059; email: ron.elliott@okstate.edu

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To receive more information about ASABE conferences and meetings, call ASABE at (800) 371-2734 or e-mail mtgs@asabe.org.

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June 22-24 World Congress of Computers in Agriculture and Natural Resources, Reno, Nevada, USA.
Oct. 11-14 Bioenergy Engineering and Operations Conference, Bellevue, Washington, USA.

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Agricultural, Chemical & Mechanical Engineers:
To consistently market the ASABE brand, we must understand the relationship between these specializations and demonstrate our unifying core competency: managing a mélange of inputs including physical, chemical, and biological systems to develop solutions that address the world’s most demanding problems while minimizing adverse impacts to the environment.

Study the 2007 ASABE Annual Report and notice interesting trends in membership. Only 8.5 percent of the membership claims biological engineering as their primary specialization. Pare that down: only 6 percent of members age 36 and older do so, while those 35 and younger are comprised of 13 percent biological engineering specialists. Go one step further: almost 20 percent of the preprofessional membership chose biological engineering as their primary specialization. Biological engineering as a specialization is the leading indicator of the changing face of ASABE.

Evolving into agricultural and biological engineers, we must ascertain key tenets, namely, incorporating the diversified systematic approach to problem-solving. To keep up with the changing world and secure the benefits that come with embracing such terms as biological, sustainability, renewable, energy, etc., we must not lose touch with traditional aspects of agricultural engineering. We cannot forget where we came from on the way to where we are going. Adding biological engineering should broaden our foundation, not build a new one. The core of ASABE will provide the mechanisms and stability necessary to apply new technologies to the sustainability model.

The word “biological” helps us identify with the “living” portion of the engineering solution to sustainable practices, while “agricultural” represents the physical system. One could argue the implications of intrinsic value for both agricultural and biological, but ultimately, our societal definition of the two should align in a way that they are equivocal in necessity. In other words, we need agricultural and biological engineering. The interaction is what will develop into the solution to sustainability. I would argue that, at present, the two are inseparable.

Driven by the market, government regulations, and personal motivation to define our legacy for the next generation, we must brand ASABE. Each member should understand his or her other role within the society. After all, we define the society. All must decide how best to represent the society within our spheres of influence. That is where the brand is developed and how the society will promote the profession as well as influence employers, government policy, licensure boards, and community.

The prognosis? Biological engineering within ASABE is on the rise. The real question is whether or not members are ready to accept the challenge of developing and implementing our brand. Our impact on the world lies in our ability to market the longstanding tradition we have applying engineering solutions to global problems. The world recognizes the need to address the sustainability battle from a systematic viewpoint. We have the opportunity to combine biological engineering with 100 years of agricultural engineering history to create a membership poised to lead the world into a sustainable future.

ASABE member John Eisenmann is an engineer at Caterpillar Inc.’s Peoria Proving Ground and chair of the Young Professionals Community and P-120 Student Organizations Committee, member of the Membership Development Council, P-126 1/4-Scale Tractor Student Design Competition Committee, ED-416 Continuing Professional Development Committee, and Vice-Chair of Programs for the Central Illinois Section, Eisenmann_John_A@Cat.com.
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