# Global Partnerships for Global Solutions:

## An Agricultural and Biological Engineering Global Initiative

The American Society of Agricultural and Biological Engineers (ASABE) has a long history of providing resources to help its member engineers solve problems in food, agriculture, natural resources, and the environment. Recognizing the need to connect its members and partner societies to address emerging challenges as a global community, ASABE implemented an initiative in 2012 toward achieving its global vision:

"ASABE will be among the global leaders that provide engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, and a healthy environment."

At the 2013 ASABE Annual International Meeting (AIM) in Kansas City, Missouri, an invited session was conducted during which members and colleagues from around the world shared critical needs in agricultural and biological engineering from their respective regions. The following year, Global Engagement Day activities at the 2014 ASABE AIM in Montreal, Quebec, Canada, began with invited remarks by internationally recognized thought leaders on the themes of sustainability, climate change, food security, energy security, and water security. The day concluded with an interactive session identifying global challenges and opportunities for agricultural and biological engineers in each of these five thematic areas.

This paper is a summary of the 2014 ASABE Global Engagement Day. It outlines the grand challenges that the world is facing, highlights the specific needs of the three "security" themes (food security, energy security, and water security) in the context of sustainability and climate change, and specifies how ASABE, its members, and its partners will address these grand challenges as the year 2050 approaches. The results of the discussions are expressed in the following goals for the Agricultural and Biological Engineering Global Initiative:

1. Improve food productivity.
2. Reduce food losses and waste.
3. Enhance energy conservation and efficiency.
4. Develop adaptable renewable energy systems.
5. Improve water availability, conservation, and efficient use.
6. Provide clean water for multiple uses (human consumption, agriculture, recreation, ecosystem services, biodiversity, etc.).


**2014 ASABE Global Engagement Day.**

© Bokgallery | Dreamstime.com

## ASABE's Global Vision

"ASABE will be among the global leaders that provide engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, and a healthy environment."

Agricultural and Biological Engineers (ABEs) strive to ensure that the necessities of life are provided in a sustainable manner. They apply engineering principles to processes associated with managing natural resources and producing agriculturally based goods. Specifically, ABEs:

- Develop solutions for responsible, sustainable uses of natural resources (soil, water, air, and energy) and agricultural products, byproducts, and wastes.
- Devise practical, efficient solutions for producing, storing, transporting, processing, and packaging agricultural products.
- Solve problems related to systems, processes, and machines that interact with humans, plants, animals, microorganisms, and biological materials.

> "Planet Earth is akin to a spaceship: all that can ever be used is already on board. It cannot be added to."
>
> K. C. Ting, Professor and Department Head, University of Illinois

And they do this with a constant eye toward economic development and improving the quality of life. The global community is now facing several megatrends, including population growth, climate change, and rapid urbanization. These megatrends are interrelated and give rise to complex global challenges, creating opportunities for ABEs to collaborate globally in developing innovative engineering and technological solutions. By seizing this opportunity, ABEs will position their profession and ASABE, their professional society, as leaders in providing solutions to the emerging global challenges.

## The Global Challenges

The United Nations Population Division (www.un.org/en/development/desa/population) has projected that the world population will grow to 9.1 billion by 2050. In response to the population growth and the increased earning power of a growing middle class, food demand is expected to double by 2050. In previous decades, increased food demand was addressed primarily through increased productivity, expansion of cultivated land, new scientific discoveries, and the proliferation of market incentives. In particular, in developed countries, a significant increase in productivity resulted from the development of machine systems to manage large-scale agriculture.

However, because 84% of global food production occurs on small-holder farms, according to the United Nations FAO (www.fao.org/publications/sofa/2014/en/), it is imperative that new solutions be found to increase the productivity of small-scale agriculture. Translating and adapting technical knowledge to local applications is a significant challenge and must consider local and regional resources, both physical and human, as well as cultural acceptability.

Urbanization, coupled with the increased earning power of a growing middle class, leads to diet transformation, including higher animal protein consumption. These changes in consumption patterns stimulate a higher demand for feed grains, which requires innovations in animal production systems. Urbanization also leads to greater food security challenges, as massive amounts of food must be moved safely and efficiently from production locations to consumers. Appropriate solutions need to be developed for countries that lack a transportation infrastructure and temperature-controlled supply chains. The trend toward urban agriculture

© Fotolia | Ilan Amith

holds much promise for supplying food to the growing urban centers in regions that lack an infrastructure for food distribution. However, many technical and social challenges must be overcome to make urban agriculture sustainable.

Water, a pillar of the Green Revolution, will continue to play a critical role in global sustainability. However, geological water is being used at an unsustainable rate. In addition, the demand for water has increased in growing urban areas. Safe, abundant water for both human consumption and food production is limited by its availability in areas of need (whether for agriculture or human needs), by the timing of its availability, and by the lack of infrastructure to treat and transport water for industrial, agricultural, and domestic purposes.

Climate variations have always impacted food production, but a decade of research on the effects of global climate change has revealed a steady drop in the productivity of selected crops. As agriculture is further affected by climate change through increasingly severe weather, modified growing seasons, and the unpredictable availability of water, agriculture must become more resilient while keeping pace with the needs of the growing population.

Energy is experiencing a changing paradigm with evolving production technologies, increasing demands, and concerns over dwindling fossil fuel reserves. As the demand for energy continues to grow, the challenge is to pursue the production of energy in alternative, renewable forms while concentrating on efficient energy use. Reliable, sustainable energy sources will be critical for industry, transportation, agricultural production, and domestic needs.

To address these challenges, ABEs can apply their unique expertise in areas such as precision agriculture, systems analysis, information technology, and environmental science. Enormous opportunities also exist as ABEs integrate their knowledge with the discoveries of others across a variety of fields to find collaborative solutions. Working with those in the discovery sciences to translate research into applications will achieve the results needed to support the Earth's burgeoning population.

## Addressing the Challenges through Five Themes

As ABEs work toward secure food, energy, and water systems, they strive to achieve sustainability of these systems in the context of climate change.

## Sustainability

Sustainability is about meeting the needs for abundant food, clean water, and adequate energy in a way that considers the long-term effects on people. Sustainability requires continuous improvement through the three-step process of defining, measuring, and implementing:

1. Defining sustainability for the enterprise, defining key performance indicators (KPIs), and selecting metrics for the KPIs.
2. Measuring the KPI metrics, setting goals for each KPI, and developing a strategy to meet the goals.
3. Implementing the strategy; measuring, assessing, and reporting the results; and then modifying the strategy to improve the outcomes.

Sustainability of agricultural systems can be achieved by increasing productivity to meet future food and fiber demands, improving the environment, and improving the social and economic well-being of agricultural communities. The KPIs for agricultural systems must be outcome based, science driven, technology neutral, and transparent. They must also combine good science with good business. The environmental KPIs for agriculture include greenhouse gas (GHG) emissions, energy use, water use, land use, water quality, nutrient use efficiency, and habitat/biodiversity.

Life cycle assessment is a technique that can be used to assess the environmental impacts associated with the various stages of a product's life, from production to consumption. For example, a recent life cycle assessment of GHG emissions for the U.S. swine production industry demonstrated a carbon footprint of 1.12 kg (2.48 lbs) of carbon dioxide equivalents ($CO_2E$) per serving. ABEs can apply their expertise in this and similar areas to improve the overall sustainability of agricultural products.

> "Sustainability is not complicated, it's just hard."
>
> Marty Matlock, Professor, University of Arkansas

On 8 July 2014, Field to Market: The Alliance for Sustainable Agriculture (www.fieldtomarket.org) announced the launch of a new agricultural supply chain program for U.S. commodity crops. The Field to Market metrics and benchmarks were developed through a platform for measuring, promoting, and reporting on continuous improvement in corn, soybeans, wheat, cotton, rice, potatoes, and other crops related to seven sustainability indicators: land use, soil conservation, soil carbon, irrigated water use, water quality, energy use, and GHG emissions. Measures like these allow ABEs to gauge the impact of agricultural practices on the global environment and on sustainability indicators.

## Climate Change

Climate change is a major global challenge that affects everyone. Increasing temperatures, higher frequency of extreme heat events, changes in drought patterns, excess rainfall and flooding, and higher atmospheric $CO_2$ concentration are already evident. If current climate trends continue, significant effects on agriculture are certain to occur. Agricultural models are valuable for estimating crop yields (and prices) as impacted by climate change. There is concern that crop commodity prices will increase significantly due in part to climate change. Ultimately, climate change may cause food and energy shortages, increased water scarcity, land degradation, and political instability.

> "What kind of world will our grandchildren experience, and what is the role of agricultural and biological engineers in shaping that world?"
>
> Robert A. Easter, President, University of Illinois

Adapting to climate change is a major challenge for agriculture. ABEs are preparing for this global challenge, but meeting the challenge will require interdisciplinary efforts. Increased collaboration with molecular geneticists and plant and animal breeders can provide varieties engineered for resiliency, sustainability, and adaptation to climate. Precision agriculture based on genetics and weather can reduce GHG emissions, increase water use efficiency, reduce environmental risks, and increase profitability. Innovations in the control of production environments for reducing GHG emissions and increasing water use efficiency are currently being pursued, and other new technologies and systems will be needed to adapt to and mitigate climate change.

## Food Security

Food security is comprised of four components: availability of a consistent food supply, access to sufficient resources to produce or purchase food, ability to store and preserve food for an adequate shelf life, and opportunity to make healthy, nutritious dietary choices. For many people in the world today, one or more of these four components are missing, and their food insecurity is a critical problem. As the global population grows toward nine billion people, the security of food systems will continue to be a challenge.

ABEs play a critical role in addressing food security by providing solutions to improve food productivity. These efficient production systems must be extended beyond the developed world. The second major area in which ABEs will influence food security is in reducing postharvest losses and food waste. Postharvest losses in many areas of the world result in up to 40% of food becoming unfit for consumption. Again, solutions developed by ABEs will be necessary to reduce these losses and preserve food. By increasing the productivity of available land and then extending the life of the food produced on the land, food security can be attained for the growing world.

## Energy Security

Energy is a critical resource for human well-being. The rate of energy consumption is strongly related to national wealth and human development. Currently, petroleum represents about one-third of total energy consumption. In 2007, U.S. oil consumption was 20.7 million barrels per day, while in 2011 it fell to 18.9 million barrels per day. During the same period, the median U.S. household income fell from $55,000 to $50,000, indicating a strong relationship between wealth and the rate of oil consumption. While U.S. energy consumption has fallen, global energy demand continues to rise, primarily due to the growing middle class in countries like China and India. It is expected that the global rate of energy consumption will continue to rise.

The Human Development Index (HDI) is a measure of a country's economic and social development and is closely correlated with energy consumption. As more countries are seeking to increase their HDI, they will require more energy to do so. Energy efficiency and conservation are essential to providing more energy overall, but they are not sufficient to meet the increasing global demands. Additional energy sources are needed.

Renewable sources of clean energy are absolutely imperative to ensure global energy security and reduce GHG emissions, and ABEs are providing solutions for energy conservation and renewable energy production. In addition, ABEs seek solutions that make food and energy production a synergistic process, rather than competing alternatives. For example, agricultural systems can co-produce food, feed, fiber, and biofuels from the same land, especially grasslands,

by utilizing corn stover or other crop residues for ethanol, and by double cropping to produce alternating food and energy crops. Using these approaches, total biomass production can be increased by 2.5 fold on the same area. Systems-based solutions like these can meet the world's energy needs as the year 2050 approaches.

### Water Security

Water security is essential for sustaining life. In evaluating water resources, water quantity and quality are the determiners of water security. Human water use is approximately 3% of all on-land annual precipitation. However, access to water is not equally distributed, and its quality is degrading around the globe. It is estimated that 3,900 children die every day from waterborne diseases, one in six people lack access to safe drinking water, and decreasing river flows are greatly affecting ecosystems and human activities. In addition, 70% of worldwide freshwater consumption is used for agricultural purposes, with that percentage varying widely in different parts of the world. For instance, 90% of total water consumption in Africa is used for agriculture, compared to only 10% in Germany and 40% in the U.S. ABEs are leaders in conserving water for agriculture and other uses, in maximizing the efficiency of water use, and in providing safe, clean water for human consumption and other purposes.

### Goals and Objectives of the Agricultural and Biological Engineering Global Initiative

The overall goal of the Agricultural and Biological Engineering Global Initiative is to provide engineering and technological solutions toward creating a sustainable world with abundant food, water, and energy, while maintaining a healthy environment. In their efforts to achieve this overall goal, ABEs focus on the following specific goals and objectives:

> "There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people, and the environment, suffer badly."
>
> World Water Council

#### *Goal 1: Improve food productivity*

Objectives:

1. Establish agricultural informatics and analytics to quantify food production.
2. Develop, adapt, and utilize scalable, regionally appropriate technologies for sustainable intensification.
3. Develop sustainable urban agricultural production systems.

#### *Goal 2. Reduce food losses and waste*

Objectives:

1. Develop methods to quantify losses in production, processing, and distribution.
2. Develop real-time prediction and monitoring of product quality and safety.
3. Design scalable, regionally appropriate harvesting, drying, storage, processing, and handling systems to minimize loss.

#### *Goal 3. Enhance energy conservation and efficiency*

Objectives:

1. Establish region-specific data and analytics to quantify energy consumption.
2. Develop, design, and deploy systems for energy-efficient crop and animal production.
3. Develop, design, and deploy scalable energy systems for crop drying and storage, and for food processing.

#### *Goal 4. Develop adaptable renewable energy systems*

Objectives:

1. Design regionally appropriate technologies for biomass and energy crop production.
2. Develop technologies and systems for biomass feedstock supply.
3. Develop biomass and food waste conversion technologies for biofuels, biopower, biomaterials, and biochemical.

#### Goal 5. Improve water availability, conservation, and efficient use

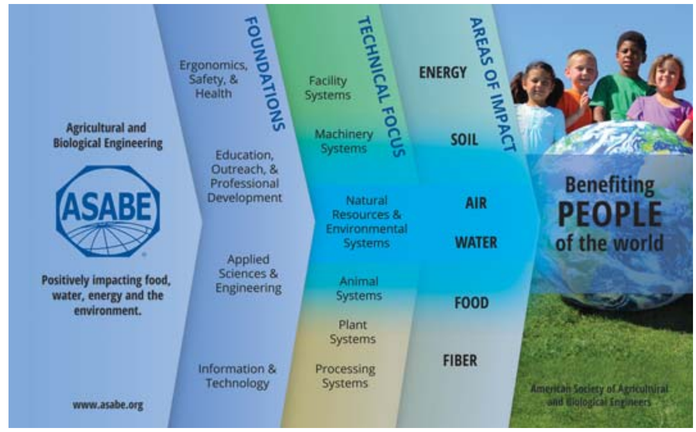
Objectives:

1. Develop affordable sensing technologies for water quality and quantity measurements.
2. Improve irrigation technologies and management to optimize water use efficiency.
3. Develop water reuse systems.

***Goal 6. Provide clean water for multiple uses (human consumption, agriculture, recreation, ecosystem services, biodiversity, etc.)***

Objectives:

1. Develop scalable, regionally appropriate, cost-effective drinking water treatment tools and systems.
2. Minimize the environmental impact of water use.
3. Develop regionally appropriate stream and wetland restoration and water pollution mitigation practices and technologies.




## ACKNOWLEDGEMENTS

### ASABE Global Challenges Forum

ASABE appreciates the contributions of the moderator and panelists for the ASABE Global Challenges Forum, held on 22 July 2013 in Kansas City, Missouri:

Robert A. Easter, President, University of Illinois (moderator)

Jong Hoon Chung, Korean Society of Agricultural Machinery

Daniella Jorge de Moura, Brazilian Society of Agricultural Engineering, and Latin American and Caribbean Association of Agricultural Engineering (ALIA)

Richard Godwin, European Society of Agricultural Engineers (EurAgEng) and U.K. Institution of Agricultural Engineers (IAgrE)

Klein Ileleji, African Network Group

Anthony Kajewski, ASABE President 2012-2013

Toshinori Kimura, Secretary General, International Commission of Agricultural and Biosystems Engineering (CIGR)

Yoshisuke Kishida, Science Council of Japan

Ta-Te Lin, Taiwan Institute of Biomechatronics

Bernardo Predicala, Canadian Society for Bioengineering (CSBE)

Yibin Ying, Chinese Society of Agricultural Engineering (CSAE) and Chinese Society for Agricultural Machinery (CSAM)

Fedro Zazueta, International Commission of Agricultural and Biosystems Engineering (CIGR).

ASABE also acknowledges the efforts of the organizing committee for the Global Challenges Forum: Lalit Verma (chair), Sreekala Bajwa, Terry Howell Jr., Sonia M. Maassel Jacobsen, Anthony Kajewski, Yoshisuke Kishida, Ajit Srivastava, K. C. Ting, Fedro Zazueta, and Darrin Drollinger.

### ASABE Global Engagement Day

ASABE appreciates the contributions of the session speakers for the ASABE Global Engagement Day, held on 15 July 2014 in Montreal, Quebec, Canada, which resulted in this paper:

Anne-Marie Boulay, WULCA Project Manager at CIRAIG - Ecole Polytechnique de Montreal

Robert A. Easter, President, University of Illinois

Bruce Dale, University Distinguished Professor, Michigan State University

James Jones, Distinguished Professor, University of Florida

Marty Matlock, Professor, University of Arkansas

Umezuruike Linus Opara, South African Research Chair in Postharvest Technology, University of Stellenbosch, South Africa.

### ASABE Global Engagement Task Force

Ajit Srivastava (chair), Sreekala Bajwa, Dorota Haman, Terry Howell Jr., Bernardo Predicala, K. C. Ting, Lalit Verma, Mary Leigh Wolfe, Fedro Zazueta, Darrin Drollinger, and Joann McQuone.

ASABE appreciates the support of the following sponsors, whose financial contributions made Global Engagement Day possible:

ADM Institute for the Prevention of Postharvest Loss
Cotton Incorporated
Global Center for Food Systems Innovation
John Deere
Kondex
Maquinas Agricolas Jacto SA