Our Commitment to Bioenergy Sustainability

The U.S. Department of Energy's Bioenergy Technologies Office (BETO) is committed to developing the resources, technologies, and systems needed to support a thriving bioenergy industry that protects natural resources and advances environmental, economic, and social benefits. BETO's Sustainability Technology Area proactively identifies and addresses issues that affect the scale-up potential, public acceptance, and long-term viability of advanced bioenergy systems; as a result, the area is critical to achieving BETO's overall goals.

BETO's sustainability work includes assessing water resource use and water quality impacts of bioenergy production. *iStock/ 7196357*

The existing and emerging biofuels industry will need to develop systems that not only meet economic and market needs, but also address environmental and social aspects such as resource availability and public acceptance. To that end, BETO supports analysis, research, and collaborative partnerships to develop and promote practices and technologies that enhance the benefits of bioenergy production activities while mitigating environmental, economic, and social concerns.

Environmental, Social, and Economic Dimensions of Sustainability

BETO is committed to growing a bioenergy industry that achieves multiple national goals:

- Displaces fossil fuels
- Enhances energy security
- Promotes local and landscape-scale environmental benefits
- Creates economic opportunities.

The Bioenergy Technologies Office's sustainability efforts are organized around environmental, social, and economic dimensions.

RESEARCH FOCUS AREAS

Climate Change & Air Quality

Analyzing biofuel pathways to quantify progress toward reducing life-cycle greenhouse gases, regulated emissions, and fossil energy use

Water Quantity & Quality

Assessing the water resource use and water quality impacts of bioenergy production, and investigating opportunities for bioenergy crops to improve water quality

Soil Quality

Developing strategies and tools for producing biomass feedstocks while maintaining or enhancing soil quality

Biological Diversity

Investigating relationships between bioenergy crops and biodiversity, and engaging with diverse experts to understand and promote practices that conserve wildlife and biodiversity

Land Use & Productivity

Advancing landscape design approaches that increase biomass production while maintaining or enhancing ecosystem services and food, feed, and fiber production

Enhancing Benefits, Addressing Challenges

BETO is identifying and addressing the challenges for sustainable bioenergy production by working with research partners to conduct field trials, applied research, capacity building, and analysis. In the area of environmental sustainability, our efforts are primarily focused on climate change and air quality, water quantity and quality, soil quality, biological diversity, and land use and productivity.

Climate Change and Air Quality

Bioenergy offers significant potential to mitigate climate change by reducing life-cycle greenhouse gas (GHG) emissions relative to fossil fuels. Although producing and burning biomass-based fuel releases carbon dioxide, biomass absorbs carbon dioxide from the atmosphere as it grows. In contrast, using fossil fuels releases carbon that has been sequestered for millennia, adding significant volumes of newly released carbon to the atmosphere. The burning of fossil fuels causes a net positive increase in atmospheric carbon.

BETO supports life-cycle analysis tools that address the entire bioenergy supply chain—from feedstock production to end use—to better understand how bioenergy development affects GHG emissions and air quality. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model was developed by Argonne National Laboratory to assess the GHG and other emissions of advanced biofuels.

Another factor to consider is local air quality, or pollutants released to the air, which should be evaluated across the bioenergy supply chain. Research at the National Renewable Energy Laboratory is quantifying air pollutant emissions (VOCs, NO_x, SO_x, NH_3, CO, PM) from feedstocks, logistics, and conversion technologies to more accurately evaluate air quality impacts of bioenergy production. Tools and analyses like these help identify which stages in the supply chain have the greatest potential for reductions in GHG and other air pollutant emissions.

Water Quantity and Quality

Expanding sustainable bioenergy production requires consideration of impacts on quantity and quality of water throughout the entire bioenergy supply chain. Sustainable bioenergy production will rely on aligning water demands with water availability, protecting water supplies and aquatic ecosystems, and maximizing the use of impaired—rather than pristine—water for producing biomass.

BETO works with national laboratories and other partners to conduct assessments of water demand for biofuel production, comparing multiple fuel types such as corn ethanol, sugarcane ethanol, cellulosic biofuels, and competing petroleum fuels. These assessments include tools like Argonne National Laboratory's Water Analysis Tool for Energy Resources (WATER), which allows users to virtually assess water resource

use and water quality across the biofuel production stages. This can help the bioenergy industry determine how to select feedstocks and conversion processes that will best fit particular contexts. Additionally, Oak Ridge and Argonne National Laboratories are conducting watershed-level analyses and field research on ways to produce bioenergy feedstocks while also maintaining or improving water quality.

Soil Quality

Producing biomass requires healthy soil that maintains productivity over time. Sustainable soil health involves minimizing soil erosion, maintaining soil carbon and other essential nutrients, and protecting the soil's physical and biological attributes. The harvest of forest and crop residues should be managed to maintain soil quality. In addition, several bioenergy feedstocks currently being considered, such as perennial grasses, show strong potential for increasing soil carbon and reducing erosion.

BETO works with the U.S. Department of Agriculture, the national laboratories, and regional partners to study management practices that achieve favorable yields while preserving soil health. For example, Idaho National Laboratory is researching how production of biomass such as agricultural residues, perennial crops, and cover crops plays a role in influencing soil, air, and water conditions. They have developed the Landscape Environmental Assessment Framework (LEAF) to determine what percentage of agricultural residues like corn stover (stalks and leaves) can be harvested while maintaining optimum soil conditions. LEAF also models alternative bioenergy production scenarios for economic feasibility and potential environmental benefits.

Biological Diversity

Growing biomass for bioenergy can either improve or reduce the diversity of plant and wildlife populations, depending on where it is grown, the existing land cover, and the way the land has been used. For example, growing native prairie grasses on degraded land can provide improved habitats for wildlife. Alternatively, growing feedstock in place of healthy native habitats can diminish biodiversity.

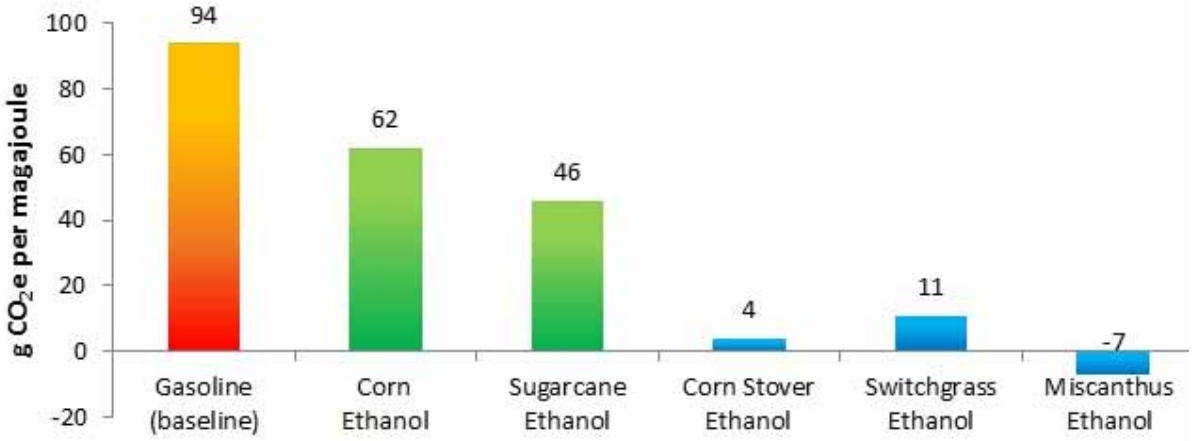
Miscanthus can be grown on degraded land and has favorable GHG reductions as a biofuel feedstock.

BETO supports analyses to understand how siting and management of bioenergy crops can maintain or improve biodiversity. For example, Oak Ridge National Laboratory is studying switchgrass production in certain areas to better understand interactions with aquatic species, which may be key indicators of stream health.

Land Use and Productivity

BETO takes an active role in improving the scientific understanding of the links between bioenergy and land use. In conjunction with the national laboratories, BETO coordinates with the environmental and scientific communities to assess model assumptions and research needs. We also are exploring how landscape design principles can be used to integrate advanced bioenergy systems into existing agricultural and forestry systems in a way that maintains food, feed, and fiber production as well as other ecosystem services of the landscape.

Farm-to-Wheels GHG Emissions



BETO supports the development of life-cycle analysis tools that help us better understand how bioenergy production affects greenhouse gas emissions relative to fossil fuels.

Source: Wang, M.; Han, J.; Dunn, J.; Cai, H.; Elgowainy, A. (2012). "Well-to-Wheels Energy Use and Greenhouse Gas Emissions of Ethanol from Corn, Sugarcane, and Cellulosic Biomass for US Use." *Environmental Research Letters* (7:4).

Commitment to Continual Improvement

BETO is committed to establishing measurable goals and priorities and monitoring for continuous improvement. Crosscutting efforts include evaluating sustainability indicators across the bioenergy supply chain, facilitating online research collaboration, enhancing social benefits such as job creation, and contributing to global scientific dialogues on bioenergy sustainability.

Bioenergy Sustainability Indicators

Photo courtesy of NREL

BETO has collaborated with researchers at Oak Ridge National Laboratory to develop a suite of indicators to measure and assess environmental and socioeconomic sustainability along the bioenergy supply chain. There are 19 environmental indicators that fit into the following categories: soil quality, water quality and quantity, greenhouse gases, biodiversity, air quality, and productivity.[1] There are 16 socioeconomic indicators, which fall into the following categories: social well-being, energy security, trade, profitability, resource conservation, and social acceptability.[2] These indicators can be used to quantify and evaluate the environmental and socioeconomic attributes of bioenergy options along the supply chain. Indicators can also be used to monitor improvements over time for different regions and bioenergy systems.

Online Toolkits and Data Resources

BETO collaborated with Oak Ridge National Laboratory to create the Bioenergy Knowledge Discovery Framework (KDF). The Bioenergy KDF supports the development of a sustainable bioenergy industry by providing access to a variety of data sets, publications, and collaboration and mapping tools that support bioenergy research, analysis, and decision making. In the Bioenergy KDF, users can search for information, contribute data, and use the tools and map interface to synthesize, analyze, and visualize information in a spatially integrated manner.

Green Job Creation

Backed by the Economic Independence and Security Act of 2007, growth in the United States biofuel industry has contributed to a substantial green-collar work force. In 2012, the ethanol industry supported an estimated 383,000 jobs,[3] including feedstock production, construction, and research. BETO facilitates the growth of these sectors through cost-shared research, development, and deployment, and measures these effects through tools like the Jobs and Economic Development Impacts (JEDI) model from the National Renewable Energy Laboratory.

International Dialogues on Sustainable Bioenergy

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BETO participates in the Global Bioenergy Partnership to contribute technical expertise and communicate the U.S. experience in evaluating and enhancing bioenergy sustainability. We also contribute technical expertise to sustainability efforts led by the International Energy Agency, the Intergovernmental Panel on Climate Change, and the International Organization for Standardization.

These international engagements accelerate research and development on sustainable bioenergy production through mutually beneficial technical exchanges and sharing of research results. These collaborations also enable BETO to stay informed of international market developments that affect the U.S. bioenergy industry, as well as help ensure that the U.S. perspective and scientific contributions are represented.

Sustainability is not an end state or specific goal; rather, BETO is committed to continuous improvement across multiple environmental, economic, and social objectives.

We collaborate with other government agencies and diverse stakeholders from industry, nongovernmental organizations, research institutions, and international bodies to define those goals and priorities. ■

1. McBride, A.C. et al. (2011). "Indicators to support environmental sustainability of bioenergy systems." *Ecological Indicators* (11); pp.1277–1289. http://web.ornl.gov/sci/ees/cbes/Publications/McBride%20et%20al%202011%20EI.pdf

2. Dale, V.H. et al. (2013). "Indicators for assessing socioeconomic sustainability of bioenergy systems: A short list of practical measures." *Ecological Indicators* (26); pp. 87–102. http://dx.doi.org/10.1016/j.ecolind.2012.10.014

3. Urbanchuk, J.M. (2015). "Contribution of the Ethanol Industry to the Economy of the United States in 2014." Agricultural and Biofuels Consulting, LLP for the Renewable Fuel Association. http://ethanolrfa.3cdn.net/94596be2e72251b795_nkm6ii26n.pdf

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