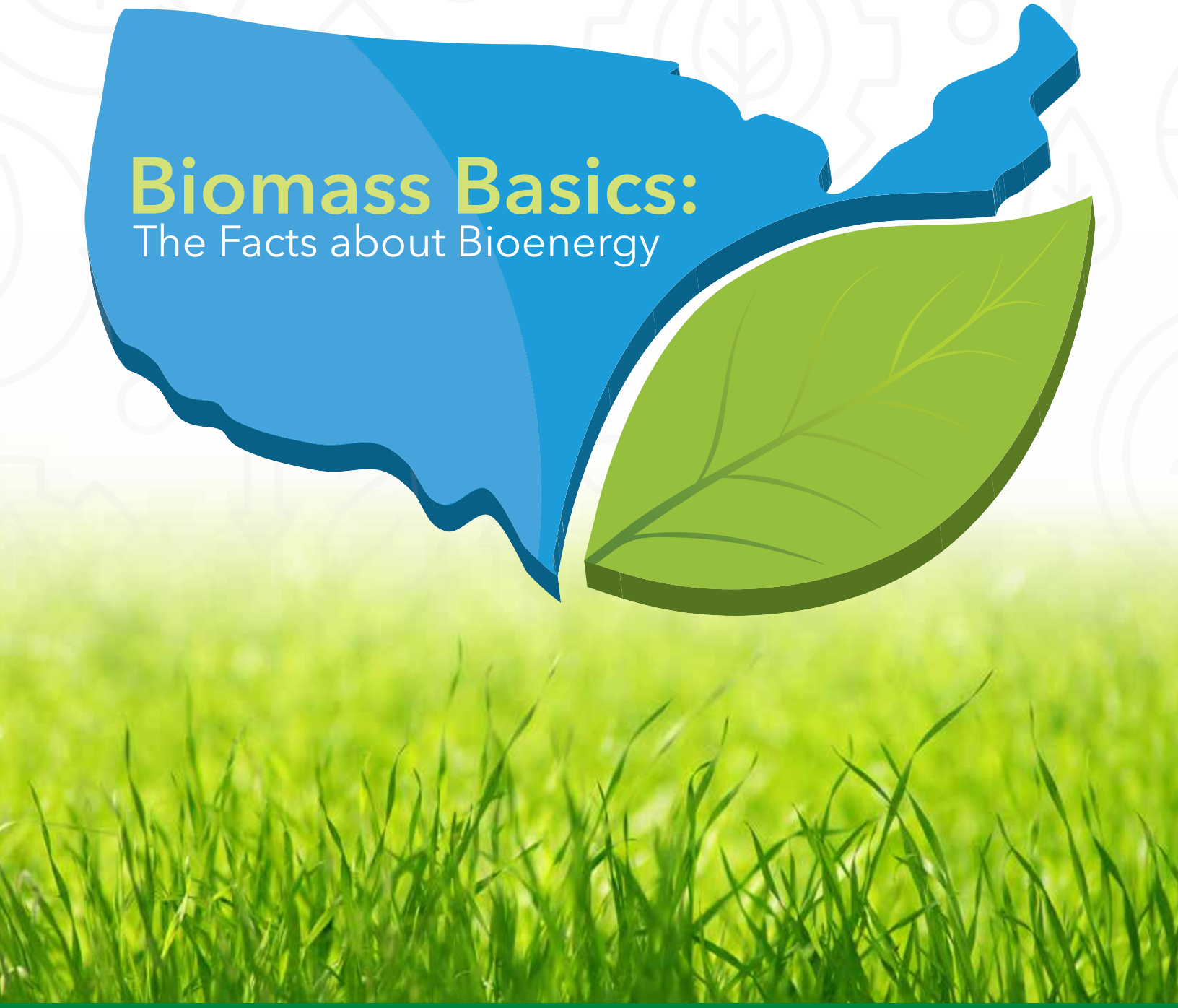
Biomass Basics:
The Facts about Bioenergy



ENERGY | *Office of* ENERGY EFFICIENCY & RENEWABLE ENERGY

BIOENERGY TECHNOLOGIES OFFICE

About this Booklet

This guide is intended to explain the basic information about bioenergy and the work that the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy's Bioenergy Technologies Office (BETO) is doing to support the energy future of the United States.

Many pages in this booklet include terms that are used in the bioenergy community. These terms are defined throughout the guide in the "Words to Know" boxes.

We rely on energy every day

Energy is essential in our daily lives. We use energy to:

- Meet transportation needs from fueling cars to fueling airplanes
- Grow food and produce other widely used products
- Heat and light our homes, schools, and workplaces
- Move goods from where they are produced to where they are bought and sold.

Most of our energy comes from petroleum, coal, natural gas, and other sources, such as **biomass**, **wet waste**, and **biogas**. National laboratories and industry partners receive funding from **BETO** to conduct research and development (**R&D**) to lower the cost of **bioenergy** production. By working with public- and private-sector partners to advance a thriving **bioeconomy**, BETO ensures American families and businesses have affordable, reliable energy and transportation options.

Words to Know

BETO
Bioenergy Technologies Office.

R&D
Research and development is the work directed toward the innovation, introduction, and improvement of products and processes.

Bioenergy
Energy produced from biomass and includes biofuels, bio-based products, and biopower.

Bioeconomy
A global transition to the sustainable use of renewable biomass resources in energy and products leading to economic, environmental, social, and national security benefits.

Words to Know

Biomass
An energy resource derived from plant material. It includes agricultural residues (such as waste from food crops and animal manures), forest resources, purpose-grown energy crops (such as algae, perennial grasses, and woody energy crops), urban wood waste, and food waste. Biomass is a unique, renewable energy resource, as it can be converted to fuels, chemicals, or power.

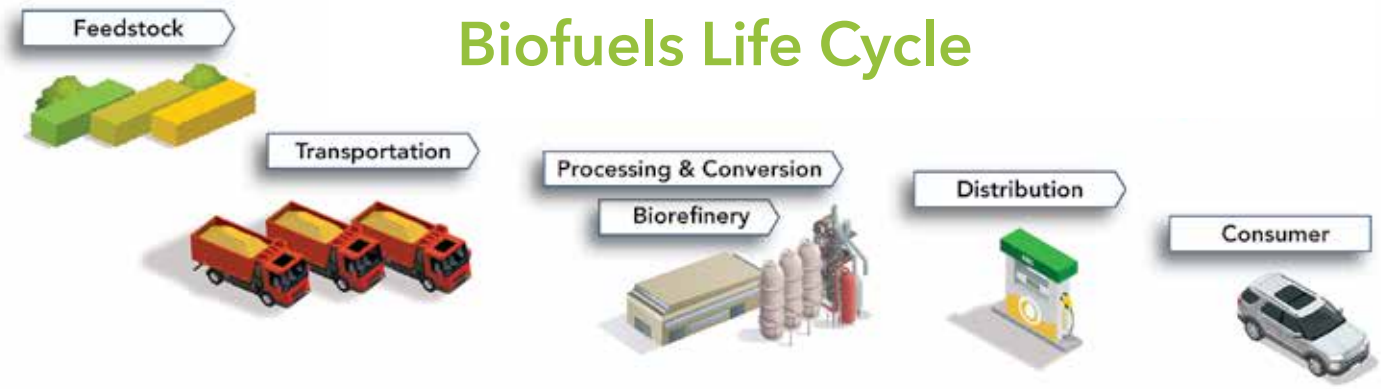
Wet Waste
Includes food waste, manures, sewage sludge, and the treated products of water treatment facilities.

Biogas
A type of biofuel that is naturally produced from gases released when organic waste breaks down with no oxygen in the environment.

BIOENERGY is an exciting, versatile energy source

Next-generation bioenergy feedstocks are promising domestic energy sources for transportation **biofuels, bioproducts,** and **biopower**. BETO focuses on new and better ways to make affordable transportation fuels, or biofuels that are compatible with current transportation infrastructure.

Biofuels Life Cycle



The biofuels life cycle begins with feedstock production and ends with a fully finished product ready for the end user.

Words to Know

Bioenergy Feedstocks
Any material used directly as a fuel or converted to another form of fuel or energy product that has undergone one or more preprocessing operations to meet the required quality characteristics for feeding into a biorefinery. Examples of preprocessing include baling, grinding, leaching, blending, pelleting, or packaging for transportation to a biorefinery.

Conventional Biomass Feedstocks
Wood and wood pellets, corn kernels, sugar cane, and other biomass materials that are harvested after a primary crop has been collected; if not used as biomass, these materials go to waste.

Next-Generation Bioenergy Feedstocks
Non-food and waste biomass materials, such as energy crops, agricultural and forestry residues, and woody residues. Next-generation bioenergy feedstocks can also include sewage, municipal solid wastes, gaseous wastes, or other organic, non-food substances.

Energy Crops
A commodity crop grown specifically for its fuel value. These can include nonfood crops such as, algae, poplar trees, or switchgrass.

Biofuels
Liquid or gaseous fuels derived from bioenergy feedstocks. Examples include ethanol, methanol, methane, and hydrogen.

Bioproducts
Materials that are derived from bioenergy feedstocks. Examples include paper, ethanol, and plastics.

Biopower
Electric power or heat derived from bioenergy feedstocks through direct combustion of the feedstock, through gasification and then combustion of the resultant gas, or through other thermal conversion processes. Power is generated with engines, turbines, fuel cells, or other equipment.

Words to Know

Drop-In Biofuels
Biofuels that are compatible with existing petroleum infrastructure.

MFSP
Refers to "minimum fuel selling price" and captures all the costs of turning biomass into an end product. It is often referred to as $/GGE, or dollar per gallon gasoline equivalent.

Cellulose
An insoluble substance that is the main portion of plant cell walls and vegetable fibers, such as cotton. Cellulose is inherently not food and is not digestible by humans.

From conventional biofuels to advanced biofuel technologies

Corn ethanol is an example of a conventional biofuel. The volume of conventional biofuels produced annually in this country is less than 20 billion gallons, a mandate set by the U.S. Environmental Protection Agency under the Renewable Fuel Standard Program Standards for 2019 and the Biomass-Based Diesel Volume for 2020.[1] To meet these standards, conventional biofuels are blended into petroleum-based fuels; for example, ethanol is blended with gasoline up to 10%. However, vehicle and equipment manufacturers, consumers, and fuel providers have concerns about the compatibility of these fuels with existing petroleum-based systems. To address these concerns, DOE is working to make **drop-in biofuels** that are compatible with existing vehicles, refinery infrastructure, and existing pipelines and trucks that move petroleum to the storage facilities at your local gas stations.

DOE is also focusing on technologies to make transportation fuels from next-generation feedstocks, which include non-food sources, for an affordable **MFSP**. The combination of conventional biofuels and advanced biofuels can provide a sustainable supply of cellulosic biofuels. Types of biofuels that can be made from **cellulose** include ethanol, diesel, and jet fuel. **Cellulosic biofuels** are an excellent alternative fuel for several reasons. They:

- *Provide domestic energy*–Cellulosic biomass is a renewable energy resource. It can be grown in nearly every state, so it does not have to be imported from other countries.
- *Minimize environmental impact*–Cellulosic biofuels, bioproducts, and biopower can be produced while minimizing the environmental impact of producing the fuel.
- *Support economic growth*–Because **biorefineries** produce multiple useful products, they open up new markets in the United States.

[1] https://www.govinfo.gov/content/pkg/FR-2018-12-11/pdf/2018-26566.pdf

Bioproducts used in our everyday lives

Up to 16%[2] of the U.S. crude oil consumption is used to produce chemicals and products, such as plastics for industrial and consumer goods, and **carbon fiber** to make vehicles more lightweight. There is an opportunity to produce a larger portion of bioproducts from biomass resources.

Biomass resources represent an important option for sustainably supplementing many petroleum-derived chemicals, plastics, and products relied upon today. Some products derived from biomass are equivalent to or even better than those made with petroleum-derived materials.

Words to Know

Cellulosic biofuels
Biofuels produced from cellulosic biomass resources, including crop residues (e.g., corn cobs, stalks), forestry residues (e.g., forest thinning, wood byproducts), energy crops (e.g., switchgrass, miscanthus), sorted municipal wastes, and algae.

Biorefineries
A facility that converts biomass or waste resources into biofuels, bioproducts, and biopower. The biorefinery concept is analogous to a petroleum refinery, where a slate of multiple fuels and products are produced from a petroleum feedstock.

Carbon fiber
A polymer manufacturing material that can be made from biomass. It is strong and lightweight and often used in industries, such as aerospace, automotive, military, and recreation.

[2] U.S. Department of Energy. 2015. *Bioproducts to Enable Biofuels Workshop Summary Report*. Washington D.C. DOE/EE-1294. https://www.energy.gov/sites/prod/files/2015/12/f27/bioproducts_to_enable_biofuels_workshop_report.pdf

Words to Know

Wet and solid wastes*
Sludge/biosolids, animal manure, food waste, and inedible fats, oils, and greases.

Gaseous wastes*
Biogas and associated natural gas.

** Primary feedstocks of interest include inedible fats and greases; biogas from landfills, dairies, and wastewater treatment plants; and the organic fraction of municipal solid wastes.*

Waste-to-energy

BETO researches how non-food biomass and waste feedstocks can be used to produce bioenergy.

Wet waste, **solid waste**, and **gaseous waste** streams are potential high-impact resources for the domestic production of biogas, biofuels, bioproduct precursors, heat, and electricity. Wastes represent a significant and underused set of feedstocks for bioenergy production. These wastes are often available without land-use change, and in many cases, their use helps to address the unique and local challenges of disposing of them.

The limited landfill capacity and other factors are necessitating innovative waste management solutions. In particular, the notion that waste streams represent valuable feedstocks for the production of biofuels, bioproducts, and biopower is beginning to rise in popularity.

Additionally, these waste streams create and emit methane as they decompose. Methane is a prevalent greenhouse gas, and there is significant potential to create monetary value from these energy-dense waste streams while simultaneously reducing harmful emissions.

U.S. energy independence, advanced manufacturing, and national security

Mobilizing domestically produced and underused non-food biomass and waste resources to produce biofuels, bioproducts, and biopower is critical to the U.S. energy strategy. Biofuel, bioproduct, and biopower production can support increased economic activity across the entire bioenergy supply chain—from new jobs in the farms and forests of the rural United States to growth in the nation's construction and manufacturing industries.

U.S. dependence on imported oil exposes the country to fuel supply disruptions, creates economic and social uncertainties for businesses and individuals, and exports revenues that could otherwise be invested in the U.S. economy. Energy resources that are produced in the United States have the capability to be available when needed.

Investing in R&D for new bioenergy technologies helps secure our national competitive advantage and enables private sector opportunities in the renewable energy field while reducing environmental impacts. BETO invests in high-impact, high-value bioenergy technology R&D projects across the United States.

BETO is committed to investing in sustainable technologies

BETO and its partners develop industrially relevant, transformative, and revolutionary bioenergy technologies to enable **sustainable**, domestically produced biofuels, bioproducts, and biopower for a prosperous nation.

Current research involves sustainable system design, which focuses on researching, developing, and testing innovative strategies that continuously improve the sustainability of bioenergy and bioproducts.

An example of this includes developing and testing landscape-design approaches that enable increased bioenergy production while maintaining or enhancing ecosystem services and other benefits, such as food, feed, and fiber production.

Words to Know

Sustainable
The aspiration to meet current needs while maintaining capacity for future generations to meet their needs. Includes being economically and environmentally viable, socially acceptable, and protective of human health and welfare.

MISSION

BETO's mission is to develop industrially relevant, transformative, and revolutionary bioenergy technologies to enable affordable, sustainable, domestically produced biofuels, bioproducts, and biopower for a prosperous nation.

LEARN MORE ABOUT THE BIOENERGY TECHNOLOGIES OFFICE

https://www.energy.gov/eere/bioenergy

19-50159-R13

ENERGY | *Office of* ENERGY EFFICIENCY & RENEWABLE ENERGY

BIOENERGY TECHNOLOGIES OFFICE

DOE/EE-2051 • April 2020