

## Growing America's Energy Future

The emerging U.S. bioenergy industry provides a secure and growing supply of transportation fuels, biopower, and bioproducts from a range of biomass resources. Abundant, renewable bioenergy can help secure America's energy future, reducing our dependence on foreign oil and ensuring American prosperity while protecting the environment.

### Program Goal

Develop technologies to enable cost-competitive production of biofuels, bioproducts, and biopower that will reduce dependence on imported oil and lower carbon emissions.

The Renewable Fuel Standard (RFS) mandates biofuel use to improve our nation's energy security. The standard requires 36 billion gallons of renewable fuels production by 2022, of which 21 billion gallons will be advanced biofuels. Meeting the RFS will require technological innovation, private investment, and clear government support in the U.S. biofuels industry over the next decade.

Success will depend on the development of efficient new systems and networks to sustainably produce, harvest, and transport large quantities of diverse feedstocks; advanced technologies to cost-effectively convert biomass to fuels; and an expanded and improved distribution and end-use infrastructure to deliver these fuels to consumers across the United States.

### Strategic Approach

The U.S. Department of Energy's (DOE) Biomass Program primarily works with industry, academic, and laboratory partners to develop advanced technologies and real-world solutions to reduce costs and spur market growth. Through a multitude of research, development, and demonstration (RD&D) projects, DOE is facilitating technology advancements that accelerate the sustainable production of clean, affordable energy. Unlocking the potential of diverse, non-food biomass resources—such as switchgrass, agricultural and forest residues, municipal waste, and algae—will yield advanced biofuels including cellulosic ethanol and renewable gasoline, aviation, and diesel fuels. These resources will also produce biopower and bioproducts.

### Sustainability

DOE's sustainability efforts address environmental, social, and economic issues along the entire bioenergy supply chain. The Biomass Program is committed to maximizing environmental benefits while mitigating concerns. Through field research, modeling, and advanced analysis, the program investigates the life-cycle impacts of bioenergy production



DOE's Biomass Program is accelerating development of a sustainable U.S. bioindustry to improve our nation's energy security, stimulate the economy, and reduce climate impacts.

*Photo artwork by BCS Incorporated*

on greenhouse gas emissions, air quality, soil quality, water, biodiversity, and land use.

### Integrated Biorefineries

Biofuels are produced in integrated biorefineries that efficiently convert a broad range of biomass feedstocks into affordable biofuels, bioproducts, and heat and power. The Biomass Program focuses its efforts on key supply chain challenges. These include developing replicable feedstock supply systems and innovative conversion technologies, both of which result in lower production costs. The program is also overcoming key supply chain challenges by developing replicable feedstock supply systems and innovative conversion technologies with lower production costs.

The success of the U.S. bioenergy industry depends in part on the quantity and quality of biomass available, as well as the industry's ability to collect, store, and cost-effectively transport it. In cooperation with several partners, the program is identifying sustainable biomass feedstock resources, developing economically viable and environmentally sound production methods, and designing feedstock logistics systems to ensure resource readiness. While the program focuses on several types of herbaceous and woody feedstocks and residues, it also supports algal feedstock R&D. Advances in algal research may lead to the sustainable production of algae-derived biofuels, opening creating new abundant, cost-effective, and sustainable domestic biomass supply.

### Integrated Biorefinery Demonstrations

The Biomass Program provides cost-shared support for construction and start-up of pilot, demonstration, and commercial-scale biorefineries that convert various feedstocks to advanced biofuels using multiple conversion pathways. These projects will validate new technology integration to produce advanced biofuels, bioproducts, and heat and power, which will reduce technical and financial risks and encourage the private investment required for commercial replication.



Biofuels will make efficient use of a broad range of biomass feedstocks across the nation. *Photo from INL*

### Conversion Processes

The Biomass Program is exploring new ways to convert feedstocks into cost-competitive liquid renewable transportation fuels. The program conducts collaborative R&D to primarily explore biochemical and thermochemical conversion as well as processes that combine the two methods.

**Biochemical Conversion** entails breaking down biomass to make carbohydrates available for conversion into sugars, which can then be converted into biofuels and bioproducts using microorganisms and other catalysts. Researchers are working to drive down the cost of pretreatment and enzymatic hydrolysis processes. They are also exploring robust new fermentation microorganisms. Future research will explore biological and chemical catalysis integration to produce a wider range of advanced fuels and products.

**Thermochemical Conversion** processes use heat and chemistry to convert biomass into a liquid or gaseous intermediate. The intermediates, such as synthetic gas and bio-oil, subsequently go through customized processing



Algae R&D focuses on genetics, strain development, cultivation strategies, and harvesting and dewatering, as well as sustainability and siting considerations.

*Photo from iStock/5312772*

to produce biopower or biofuels, such as gasoline, diesel, and jet fuel. Researchers are focusing on cost-effective options for gas and bio-oil cleanup, development of high-yield catalysts for fuel synthesis, and other thermochemical routes to biofuels that compatible with existing petroleum infrastructure.



The program is currently supporting development of cellulosic ethanol as well as renewable gasoline, diesel, and jet fuels.

*Photo from BCS Incorporated*

### Distribution and End Use

The Biomass Program works with industry, academia, and other government agencies to help create market conditions amenable for biofuels to safely, cost-effectively, and sustainably reach consumers while displacing petroleum. Integrating increasing volumes of biofuels into the nation's fuel supply will require improved downstream infrastructure capacity to transport, store, and distribute these fuels to consumers. Work in this area includes economic and geospatial evaluation of U.S. biofuels distribution infrastructure needs. Recently funded projects include research and testing on intermediate ethanol blends, deployment of strategically located E85 retail pumps, and development of geospatial tools designed to analyze biomass resource locations and routing options while reducing biofuels delivery costs.

### Bioenergy Industry Creates Green Jobs

A robust bioenergy industry will be the source of a variety of jobs across several sectors, from farming and trucking to biochemical engineering and microbiology. The sector is projected to stimulate significant job growth.

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