

The Bioenergy Technologies Office (BETO) supports early-stage applied research and critical, research-integrated pilot-scale development on the production of high-performance biofuels, bioproducts, and biopower derived from the nation’s abundant, domestic, renewable biomass resources.

Economic Highlights

BETO innovations stimulate the U.S. economy, job growth, and competitiveness.

- The 2014 report, *Economic Impact Analysis of the U.S. Biobased Products Industry*, estimates that the bio-based products industry has added \$393 billion to the economy, while supporting 4.2 million direct jobs.
- BETO research and development (R&D) supports the bio-economy which has the potential to produce 1 billion tons of biomass annually in the U.S. to advance the production of power, chemicals, and fuels, adding:
 - 1.1 million more direct American jobs and about \$260 billion in U.S. revenue
 - 75 billion kilowatt hours of domestic electricity to power 7 million households
 - 50 billion gallons of biofuels, potentially displacing almost 25% of imported transportation fuels
 - 50 billion pounds of biobased chemicals and bioproducts, replacing a significant portion of the chemical market.

FY 2018 Priorities

FY 2018 Program Focus

- BETO will concentrate on early-stage applied R&D to enable cost-competitive, higher-performing drop-in biofuels and bioproducts, to achieve \$3 per gasoline gallon equivalent (gge) drop-in biofuels in the near-term, and analyze R&D pathways to achieve \$2/gge.

Program Strategy

- R&D will focus on conversion and the feedstock-conversion interface to reduce cost, improve process yields, and develop pathways for high-value, high-performance fuels and products.
- Prioritize unique national laboratory capabilities to advance early-stage research, including through multi-laboratory consortia.
- Accelerate results through cooperative R&D agreements (CRADAs) with university and industry partners.

Activity Highlights

- Advanced Algal Systems – Multi-lab consortia will explore algae strains to improve productivity and yield.

- Feedstocks and Supply Logistics – Research to improve the quality and consistency of scalable bioenergy feedstocks and reduce the delivered cost to \$84/ton, with an emphasis on feedstock-conversion interface R&D to improve process yields.
- Conversion – Applied early-stage research in synthetic biology of engineered organisms and development of new, novel catalysts to improve yields and selectivity of renewable chemicals and drop-in biofuels.
- Advanced Development and Optimization – Applied R&D in the co-optimization of fuels and engines to develop bio-based fuels and additives that enable 15% to 20% fuel economy gain when blended with petroleum and used in high-efficiency engines.
- Strategic Analysis and Sustainability – Analyze pathways and R&D strategies capable of achieving \$2/gge. Research sustainability to identify strategies for increasing bioenergy production without detriment to food security, air, land, and water resources.

FY 2018 Budget Request

Budget Authority (Dollars in Thousands)	FY 2018 Request
Feedstock Supply and Logistics	6,000
Advanced Algal Systems	5,000
Conversion Technologies	34,600
Advanced Development and Optimization (formerly Demonstration and Market Transformation)	6,000
Strategic Analysis and Cross-Cutting Sustainability	5,000
Total, Bioenergy Technologies	56,600

BETO early-stage R&D is enabling creation of a robust, next-generation domestic bioenergy industry that will provide Americans with fuel diversity, job opportunities, and a global market competitive advantage.

Major Accomplishments and Goals

BETO early-stage R&D will accelerate applications and accessibility of new, high-performing bioenergy technologies.

- Develop transformative and revolutionary sustainable bioenergy technologies to enable domestically-sourced, cost-competitive bio-derived fuels and chemicals.
- By 2018, achieve a cost target for renewable hydrocarbon (HC) fuel at \$3/gge and an \$84/dry-ton (2014) cost of feedstock.
- By 2022, verify two HC bio-fuel production pathways at a modeled price of \$3/gge.
- By 2025, reduce the time and cost for developing new organisms and catalysts by at least 50%.
- By 2027, verify a \$1/gge fuel reduction cost for the production of biofuels and bioproducts by validating conversion-process waste streams and producing novel bioproducts.

BETO supports practical R&D for businesses and consumers.

- In 2012, BETO R&D verified a modeled cellulosic ethanol price at approximately \$2/gallon of ethanol.

- BETO prior R&D and scale-up led to construction of pioneer commercial facilities, such as POET and DuPont, with the potential for 88 million gallons per year capacity.

In the past five years, BETO shifted focus to HC fuels to supplement diesel, jet, and gasoline as well as bio-products.

Recent BETO successes include –

- Lygos' commercialization of malonic acid for use in chemicals/polymers and \$13.4 million financing.
- DOE/U.S. Department of Agriculture collaboration supporting Red Rock technology, leading to a commercial fuel purchase agreement with Southwest Airlines for 3 million gallons per year of bio-based jet fuel.
- Zobi Harvester, in partnership with Global Algae, providing efficient, energy and cost-effective dewatering of algal systems to a 20% slurry solution, which is now available commercially.
- BETO has shown a 70% reduction in modeled mature fuel selling price for drop-in biofuels from fast pyrolysis of woody feedstock and upgrading, since 2009.

Success Stories

Virent transforms biomass into affordable, domestically-produced renewable fuels and chemicals. DOE has provided critical support to Virent, which catapulted an academic bioenergy concept into a commercial success.

Virent's technology, BioForming, developed in 2001 at the University of Wisconsin, allows for the conversion of waste feedstocks (cellulosic biomass) into "drop-in" fuels. This patented technology features catalytic chemistry to convert plant-based materials into products identical to those made from petroleum, including gasoline, diesel, jet fuel, and chemicals for plastics and fibers. The products are drop-in replacements enabling utilization of existing logistics infrastructure without blending limitations.



BioForming technology can be used to make renewable chemicals, most notably para-xylene, a key component in polyester and a precursor to polyethylene terephthalate (PET). Virent is partnering with **Coca-Cola** to produce the first 100% plant-based reusable PET bottles by 2020 (over 35 billion bottles). Virent established a consortium with **Tesoro**, **Toray**, **Johnson Matthey**, and **Coca-Cola** to deliver a commercial facility to produce low cost bio-based fuels and bio-paraxylene.

ENSYN, in partnership with **Petrobras** and **EERE's National Renewable Energy Laboratory (NREL)**, demonstrated the technical and economic feasibility of co-processing raw, pine-derived pyrolysis oil with fossil feedstocks in an oil refinery's Fluid Catalytic Cracker (FCC) operation to produce renewable hydrocarbon fuels. Data and analysis from this BETO-sponsored project revealed the potential to leverage the existing 6 million oil barrel per day U.S. refinery FCC processing capacity, which could create 72,000 short-term construction jobs and 21,000 permanent operations jobs.



← Stabilized Pyrolysis Oil



← Petrobras Refinery

The project results enabled California's Air Resources Board (ARB) to grant Ensyn key regulatory approvals for the use of Ensyn's Renewable Fuel Oil (RFO™) as a renewable feedstock for refineries in California for the production of renewable gasoline and diesel. The approvals were granted in accordance with California's Low Carbon Fuel Standard.

Ensyn, Chevron U.S.A., Inc., and Tesoro Corporation were co-applicants in this process. Data generated under the BETO project enabled approval for Ensyn's Co-Processed Diesel and Gasoline to be sold under Clean Air Act regulations for the sale of co-processed fuels into U.S. commerce.